HIGH TECH TRASH

Digital Devices, Hidden Toxics, and Human Health

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CHAPTER ONE

The Underside of High Tech

The rapidity of change and the speed with which new situations are created follow the impetuous and heedless pace of man rather than the deliberate pace of nature.[1]
—Rachel Carson, *Silent Spring*, 1962

If future generations are to remember us with gratitude rather than with sorrow, we must achieve more than just the miracles of technology. We must leave them a glimpse of the world as God really made it, not just as it looked after we got through with it.[2]
—President Lyndon B. Johnson, 1965

A harbor seal arches her back and dives, a graceful comma of brown on the steel blue water of San Francisco Bay. A school of herring darts through the saltwater off the coast of Holland. A polar bear settles down to sleep in a den carved out of Arctic ice. A whale cruises the depths of the North Sea and a chinook salmon noses her way into the Columbia River on her way home to spawn. In the Gulf of Mexico, a bottlenose dolphin leaps above the waves. A seagoing tern lays an egg. A mother in Sweden nurses her baby, as does a mother in Oakland, California. Tissue samples taken from these animals and from these women's breasts contain synthetic chemicals used to make the plastics used in computers, televisions, cell phones, and other electronics resist fire. Americans have the highest levels of these compounds in their blood of any people yet tested, and the same chemicals have been found in food purchased in grocery stores throughout the United States.

On the shores of the Lianjiang River in southern China, a woman squats in front of an open flame. In the pan she holds over the fire is a smoky stew of plastic and metal—a melting circuit board. With unprotected hands she plucks out the microchips. Another woman wields a hammer and cracks the glass of an old computer monitor to remove the copper yoke. The lead-laden glass screen is tossed onto a riverside pile. Nearby, a man sluices a pan of acid over a pile of computer chips, releasing a puff of toxic steam. When the vapor clears a small fleck of gold will emerge. Up and down the riverbanks are enormous hillocks of plastic and metal, the discarded remains of electronic appliances—monitors, keyboards, wires, printers, cartridges, fax machines, motors, disks, and cell phones—that have all been exported here for inexpensive, labor-intensive recycling. A bare-legged child stands on one of the mounds, eating an apple. At night, thick black smoke rises from a mountain of burning wires. In the southern Chinese city of Guiyu—one of the places in Asia where this primitive recycling takes place—an estimated 80 percent of the city's 150,000 residents are engaged in processing the million or more tons of electronic waste that have been arriving there each year since the mid-1990s.[3]

Mines that stretch for miles across the Arizona desert, that tunnel deep under the boreal forests of northern Sweden, and others on nearly every continent produce ore and metals that end up in electronic gadgets on desktops, in pockets, purses, and briefcases, and pressed close to ears all around the world. In a region of the Democratic Republic of the Congo wracked by horrific civil war, farmers have left their land to work in lucrative but dangerous, landslide-prone coltan mines. Sales of this ore, which is used in the manufacture of cell phones and other devices, have helped finance that war as well as the fighting between Uganda and Rwanda in this mineral-rich region of Africa. Although they are mostly hidden, metals make up over half the material in the world's 660 to 700 million computers. A typical desktop computer can contain nearly thirty pounds of

metal, and metals are used in all electronics that contain semiconductors and circuit boards (which are themselves 30 to 50 percent metal)—from big plasma screen TVs to tiny cell phones. Extracted and refined at great cost, about 90 percent of the metal that goes into electronics eventually ends up in landfills, incinerators, or some other kind of dump.

Traffic on the highway that runs between San Francisco and San Jose is bumper to bumper. Haze rises from the vehicle-clogged road. Office plazas, strip malls, and housing developments stretch out against the backdrop of hills that frame the valley. Pooled beneath the communities of Santa Clara, Cupertino, and Mountain View, California—to name but a few—are thousands of gallons of poisonous volatile organic compounds left by the manufacture of semiconductors. California's Silicon Valley now has more toxic waste sites subject to cleanup requirements under the federal government's Superfund program than any other region of comparable size in the United States. In parts of Mountain View, the U.S. Environmental Protection Agency (EPA) has found in groundwater levels of trichloroethylene (TCE)—a solvent used in semiconductor production that the EPA recognizes as a carcinogen—that may be sixty-five times more toxic than previously thought.[4] Official estimates say it will take decades, if not a century or more, to complete the cleanup. Families in Endicott and other communities in Broome and Dutchess counties in upstate New York are grappling with the same problem, living above a groundwater plume contaminated for over twenty years with TCE and other solvents used in microchip manufacture.

In the high desert country of New Mexico, the ochre and mustard colored cliffs of the Sandia Mountains rise above the Rio Grande valley. Globe mallow and prickly pear sprout from the sandy soil. This is the third most arid state in the nation, and the past decade has been marked by drought. Yet one of the handful of semiconductor manufacturers located near Albuquerque has been using about four million gallons of water a day—over thirty times the water an average American household uses annually[5]—while sending large quantities of toxics into the local waste stream. Similar scenarios have emerged in other parts of the country where semiconductor manufacture has taken place—among them, the Texas hill country around Austin, the Boston area landscape that gave rise to the American Revolution, and the suburban sprawl that surrounds Phoenix. Residents of Endicott, New York, and Rio Rancho, New Mexico, have asked the Agency for Toxic Substance and Disease Registry (part of the U.S. Department of Health and Human Services) to assess the health impacts of hazardous air pollutants—including trichloroethylene, methanol, ethylene chloride, and several perfluorocarbons—emitted by high-tech manufacturers located in their communities.

Semiconductors come off the assembly line in numbers that dwarf other manufactured products, but because microchips are so tiny, we're less inclined to think about their environmental footprint. One of Intel's Pentium 4 chips is smaller than a pinky fingernail and the circuit lines on the company's new Itanium 2 chips are smaller than a virus—too small to reflect a beam of light.[6] Producing something of this complexity involves many steps, each of which uses numerous chemicals and other materials and a great deal of energy. Research undertaken by scientists at United Nations University and the National Science Foundation found that at least sixteen hundred grams of fossil fuel and chemicals are needed to produce one two-gram microchip. Further, the secondary material used to produce such a chip amounts to 630 times the mass of the final product, a proportion far larger than for traditional low-tech items.[7] In 2004 some 433 billion semiconductors were produced worldwide.[8]

The Information Age. Cyberspace. The images are clean and lean. They offer a vision of business streamlined by smart machines and high-speed telecommunications and suggest that the proliferation of e-commerce and dot-coms will make the belching smokestacks, filthy effluent, and slag heaps of the Industrial Revolution relics of the past. With this in mind communities everywhere have welcomed high technology under the banner of "clean industry," and as an alternative to traditional manufacturing and traditional exploitation of natural resources. But the high-tech industry is far from clean.

Sitting at my desk in Portland, Oregon, the tap of a few keys on my laptop sends a message to Hong Kong, retrieves articles filed in Brussels, shows me pictures of my nieces in New York, and plays the song of a wood stork recorded in Florida. Traveling with my laptop and cell phone, I have access to a whole world of information and personal communication—a world that exists with increasingly little regard to geography, as electricity grids, phone towers, and wireless networks proliferate. This universe of instant information, conversation, and entertainment is so powerful and absorbing—and its currency so physically ephemeral—that it's hard to remember that the technology that makes it possible has anything to do with the natural world.

But this digital wizardry relies on a complex array of materials: metals, elements, plastics, and chemical compounds. Each tidy piece of equipment has a story that begins in mines, refineries, factories, rivers, and aquifers and ends on pallets, in dumpsters, and in landfills all around the world.

Over the past two decades or more, rapid technological advances have doubled the computing capacity of semiconductor chips almost every eighteen months, bringing us faster computers, smaller cell phones, more efficient machinery and appliances, and an increasing demand for new products. Yet this rushing stream of amazing electronics leaves in its wake environmental degradation and a large volume of hazardous waste—waste created in the collection of the raw materials that go into these products, by the manufacturing process, and by the disposal of these products at the end of their remarkably short lives.

Thanks to our appetite for gadgets, convenience, and innovation—and the current system of world commerce that makes them relatively affordable—Americans, who number about 290 million, own over two billion pieces of high-tech consumer electronics: computers, cell phones, televisions, printers, fax machines, microwaves, personal data devices, and entertainment systems among them.[9] Americans own over 200 million computers, well over 200 million televisions, and over 150 million cell phones.[10] With some five to seven million tons of this stuff becoming obsolete each year,[11] high-tech electronics are now the fastest growing part of the municipal waste stream, both in the United States and in Europe.[12] In Europe, where discarded electronics create about six million tons of solid waste each year, the volume of e-waste—as this trash has come to be called—is growing three times faster than the rest of the European Union's municipal solid waste combined.[13]

Domestic e-waste (as opposed to e-waste imported for processing and recycling) is accumulating rapidly virtually everywhere in the world that PCs and cell phones are used, especially in populous countries with active high-tech industries like China—which discards about four million PCs a year[14]—and India. The United Nations Environment Programme estimates that the world generates some twenty to fifty million metric tons of e-waste each year.[15]

The *Wall Street Journal*, not known for making rash statements about environmental protection, has called e-waste "the world's fastest growing and potentially most dangerous waste problem."[16] Yet for the most part we have been so bedazzled by high tech, adopted its products with such alacrity, been so busy thriving on its success and figuring out how to use the new PC, PDA, TV, DVD player, or cell phone, that until recently we haven't given this waste—or the environmental impacts of manufacturing such products—much thought.

Compared to waste from other manufactured products, particularly the kind we are used to recycling (cans, bottles, paper), high-tech electronics—essentially any appliance containing semiconductors and circuit boards—are a particularly complex kind of trash. Soda cans, bottles, and newspapers are made of one or few materials. High-tech electronics contain dozens of materials—all tightly packed—many of which are harmful to the environment and human health when discarded improperly. For the most part these substances do not pose health hazards while the equipment is intact. But when electronics are physically damaged, dismantled, or improperly disposed of, their toxics emerge.

The cathode ray tubes (CRTs) in computer and television monitors contain lead—which is poisonous to the nervous system—as do circuit boards. Mercury—like lead—a neurotoxin, is used in flat-panel display screens. Some batteries and circuit boards contain cadmium, known to

be a carcinogen. Electronics contain a virtual alphabet soup of different plastics, among them polystyrene (HIPS), acrylonitrile butadiene styrene (ABS), and polyvinyl chloride (PVC). A typical desktop computer uses about fourteen pounds of plastic, most of which is never recycled. PVC, which insulates wires and is used in other electronic parts and in packing materials, poses a particular waste hazard because when burned it generates dioxins and furans—both persistent organic pollutants.[17] Brominated flame retardants, some of which disrupt thyroid hormone function and act as neurotoxins in animals, are used in plastics that house electronics and in circuit boards. Copper, antimony, beryllium, barium, zinc, chromium, silver, nickel, and chlorinated and phosphorus-based compounds, as well as polychlorinated biphenyls (PCBs), nonyphenols, and phthalates, are some of the other hazardous and toxic substances used in high-tech electronics. A 2001 EPA report estimated that discarded electronics account for approximately 70 percent of the heavy metals and 40 percent of the lead now found in U.S. landfills.[18]

In many places, solvents that have been used in semiconductor manufacture—trichloroethylene, ammonia, methanol, and glycol ethers among them—all of which adversely affect human health and the environment, have ended up in local rivers, streams, and aquifers, often in great volume. Semiconductor production also involves volatile organic compounds and other hazardous chemicals—including methylene chloride, Freon, and various perfluorocarbons—that contribute to air pollution and can potentially adversely affect the health of those who work with them. Numerous lawsuits have already been brought by high-tech workers who believe their health or their children's has been harmed by chemicals they were exposed to in high-tech fabrication plants.

Manufacturing processes and materials change continually and at a pace that far outstrips the rate at which we assess their environmental impacts—particularly in the realm of chemicals, where new compounds are introduced almost daily. Health and safety conditions throughout the high-tech industry have improved over the years, and the business has become more transparent. But the way in which the United States goes about assessing risks posed by chemicals used in high-tech manufacture has not changed, and many of the environmental and health problems now being dealt with were caused by events that took place over twenty years ago.

Despite the enormous quantity of electronic waste generated, and the fact that we have been producing this trash at accelerating rates since the 1970s, regulations and systems for dealing with this refuse have only recently been developed and put to work. In this, government policies regulating e-waste in the United States lag conspicuously behind those in Europe and Japan. As of this writing, about a dozen individual countries regulate the disposal of e-waste.[19] Over half of those have national systems to collect high-tech and other electronics products for recycling; the United States is not among them. As of 2006 it is mandatory throughout the European Union (although some countries have delayed compliance) and companion legislation restricts the use of certain hazardous substances in electronic products. A 2003 report by the International Association of Electronics Recyclers found that only 9 percent of Americans' discarded consumer electronics were being recycled.[20] Given the volume of electronics purchased and discarded in the United States, that we rely on voluntary measures to keep high-tech trash from harming the environment is like using a child's umbrella to stay dry during a monsoon.

And despite international regulations designed to prevent the export of hazardous waste from richer to less well-off countries, an estimated 80 percent of a given year's electronic waste makes its way from countries like the United States and the United Kingdom to poorer countries—like China, Pakistan, India, and those in west Africa—where huge amounts of equipment are dismantled in unsafe conditions or are discarded in ways acutely harmful to the environment.[21] No auditable figures are available, but industry experts estimate that about half a million tons of electronics are recycled in the United States annually.[22] Because this is no more than a tenth of what is discarded, somewhere between two and four million tons of e-waste from the United States alone has likely been making its way overseas each year for low-tech recycling. A recent study of e-waste in southern China found that about 75 percent of the electronics being processed there came from the United States.[23]

Some forty years have passed since Rachel Carson caught the world's attention with *Silent Spring*. A number of the synthetic chemicals Carson wrote about are now banned, but we continue to create new compounds with persistent adverse environmental and health impacts. Some of these manufactured substances are used to produce high-tech electronics, products that have become virtually ubiquitous throughout the developed world. Many high-tech electronics contain substances whose environmental impacts—local, global, short and long term—have not been dealt with before and which we do not yet understand. As we become increasingly dependent on the rapid electronic transfer of information, while telling ourselves that we are moving beyond the point where economies depend on the obvious wholesale exploitation of natural resources, we are also creating a new world of toxic pollution that may prove far more difficult to clean up than any we have known before.

That we have ignored the material costs of high tech is not surprising. Historically, industrial society has externalized many of the costs associated with its waste, expecting these costs to be borne not by manufacturers or purchasers of the products, but by communities and absorbed by the environment. Until the passage of clean air and water laws, industry could dump its effluent without expecting to be responsible for the consequences. In many ways high tech is a manufacturing industry like any other. But its public profile is very different from that of traditional industries. Because high tech enables us to store encyclopedias' worth of information on something smaller than a donut, we have—until very recently—overlooked the fact that miniaturization is not dematerialization.

As an illustration consider this passage from *Being Digital* by Nicholas Negroponte, published in 1995, which aptly characterizes the bloom and boom of high-tech culture and how our thinking about high tech tends to divorce the machinery from the information it transmits. (Caveat: In computer-chip generations, a statement about the Digital Age written ten years ago is like looking back at a view of the world penned during the

Roaring Twenties—and my aim is not to quarrel with or single out Mr. Negroponte for having made this observation.)

> The slow human handling of most information in the form of books, magazines, newspapers and videocassettes, is about to become the instantaneous and inexpensive transfer of electronic data that move at the speed of light . . . Thomas Jefferson advanced the concept of libraries and the right to check out a book free of charge. But this great forefather never considered the likelihood that 20 million people might access a digital library electronically and withdraw its contents at no cost.[24]

The point Negroponte, a professor of media technology at MIT, wished to emphasize was digital technology's potential to make information universally accessible, presumably without a cash transaction or equivalent thereof. Yet the phrase "at no cost" leaps out because it reinforces the perception that these digital gadgets perform their marvels with no material impacts whatsoever.

Where the garbage goes; where a plume of smoke travels; where waste flows and settles when it gets washed downstream; how human communities, wildlife, and the landscape respond to waste. These are costs traditionally outside the scope of the industrial balance sheet and that industry is just beginning to figure into the cost of doing business. As Jim Puckett, director of Basel Action Network, a Seattle-based nonprofit that tracks the global travels of hazardous waste, told me in 2004, "Humans have this funny idea that when you get rid of something, it's gone." The high-tech industry is no exception.

Laws regulating industrial waste have begun to protect human health and the environment from what comes out of chimneys and drainpipes, yet with few exceptions (e.g., state bottle bills) there is little mandatory collection of used consumer products in the United States. Manufacturers bear little responsibility for the post-consumer disposal of their finished products, and there are few industry-specific, legally binding bans on the use of toxic materials. But in the European Union, laws that become effective in 2005 and 2006 will require manufacturers to take back used electronics for recycling and to eliminate certain hazardous substances from their products. These regulations—known as the WEEE (Waste Electrical and Electronics Equipment) and RoHS (Restriction on the use of Certain Hazardous Substances) directives—are influencing what happens in the United States. Given the global nature of the high-tech industry, these materials standards will, in effect, become world standards, as it's simply not practical to have different manufacturing streams for individual markets.

High tech may thus become one of the first industries being seriously pushed to internalize the costs of waste throughout the products' life cycle and to design products with fewer adverse environmental impacts.

As of the end of 2005, the United States remains far from enacting any national e-waste legislation.[25] Yet over the past several years, more than half of all states have introduced some sort of e-waste bill. Meanwhile, most major high-tech manufacturers have set up some kind of take-back programs to facilitate recycling and reuse of their products. Manufacturers have also been teaming up with retailers, nonprofits, and local governments to hold used-electronics collection events. However, the burden of finding and using these programs still lies entirely with the consumer, and many are far more cumbersome, limited, and costly than comparable programs in Europe and Japan. And despite the fact that the United States has the highest per capita concentration of PCs, research published in early 2005 discovered that 95 percent of American consumers do not know the meaning of "e-waste" and 58 percent are not aware of an electronics recycling program in their community.[26]

However we cope with high-tech trash from now on, it's important to remember that many generations of this waste have already entered the global environment. As long ago as 1964 President Lyndon B. Johnson cautioned, "The bright success of science also has a darker side." We must, he said, "control the waste products of technology."[27] But virtually none of the books chronicling the rise of high technology or high tech's social and cultural influences consider the industry's impacts on human health or the environment. While knowledge of these impacts has existed for much longer, it has only been since the late 1990s that the world has begun to confront the environmental realities of high-tech manufacturing and e-waste in any substantive way.

Spurred by shocking pictures of this waste, the persistence of contaminated groundwater, serious health concerns about chemical exposure, and troubling scientific discoveries, we're scrambling to catch up. There are many reasons why we have allowed high-tech trash to pile up and pollute. Some are commercial: the historic practice of letting consumers and communities bear the burdens of waste. Some are political: the sway business and industry hold over public policy, particularly in the United States. And some are cultural: our embrace of the new, which seems to go hand in hand with our acceptance of all things disposable. It hasn't helped us come to grips with high tech's waste that when thinking about high tech many of us blur the distinction between hardware and software, forgetting that in addition to armies of computer-science jocks encoding the next operating system or search engine, high tech also means tons of chemicals, metals, and plastics. The problems created by high-tech trash, however, cannot be blamed on ignorance of the harm caused by industrial and chemical pollution, for by the time the high-tech industry came of age, professional knowledge and public consciousness of industrial pollution had been thoroughly raised.

The tangible effects of e-waste and the environmental and health impacts of high-tech manufacture may be out of sight for many people, but this is by no means a story of abstractions or problems so remote that they can be safely shelved. Nor is it a story that hinges on hair-splitting analyses of risk or an issue frothed up by worried advocates who yearn for simpler times. This is a story in which we all play a part, whether we know it or not. Information-age technology has linked the world as never before, but its debris and detritus span the earth as well. From product manufacture and marketing, raw material collection, order fulfillment, disposal and recycling—and because the cultures and politics of Europe, Asia, and the Americas influence what we consider waste and how we treat it, and because ecosystems do not respect political boundaries—this is an international story. If you sit at a desk in an office, talk to friends on your cell phone, watch television, listen to music on headphones, eat cheese bought

in a supermarket almost anywhere in America, are a child in Guiyu, or a native of the Arctic, you are part of this story.

This is probably a good place to interject that I am not a Luddite and that this book will not be an exercise in technology bashing. I am not anti-computer, I do not hate cell phones, abhor e-mail, or despise the Internet. Like most first-world citizens of the twenty-first century, I rely on these devices for much of my work, some entertainment, and personal communication. But I do not believe that "smart machines" and high-tech electronics can solve problems on their own or that they can replace human or natural creation and interaction. They are simply tools, to be used wisely and with inspiration, or not, as the case may be. The point of this book's investigations is not to condemn high technology, computers, and all their electronic relations, but to explore how the material demands of the digital age—as currently configured—are affecting the natural world and the health of human communities and how these problems are being addressed.

My interest in high-tech waste began a few blocks from my house, on the banks of the Willamette River in Portland, Oregon. In 2000 I wrote a report for Willamette Riverkeeper, a nonprofit river conservation group, investigating the toxics released directly into the Willamette. Thanks to decades of public outcry about the state of the river, many of the older pollutants—sewage, wood-products, and canning waste—that fouled the river for generations had been greatly reduced or eliminated. We wanted to find out how that progress might be holding up. Using information available through the EPA's Toxics Release Inventory (reporting required of industries that use over a certain volume of toxics monitored by the EPA), we discovered that between 1995 and 1997 alone the volume of toxics released directly into the Willamette Basin doubled, as did the amount of these toxics diverted to public treatment plants. The largest volumes of these chemicals came from factories producing semiconductors and from those processing metals, chemicals, and other materials for high-tech products.[28]

As in other communities around the country, high tech had been encouraged to settle in Oregon's Willamette Valley—part of the Pacific Northwest sometimes referred to as the Silicon Forest. The discovery that the high tech—a great economic, and in many ways, social and cultural boon to the Northwest and an industry commonly considered a "clean" or "green" alternative to timber and paper—was a major source of toxic pollution surprised all who read the report.

Since 2000, the world's awareness of e-waste and its impacts has burgeoned. Electronics recycling has become law in Europe and Japan, and manufacturers are racing to meet the European Union's 2006 deadline for eliminating certain toxics from their products. In 2002 ten U.S. states considered legislation concerning disposal of e-waste. In 2003 over fifty such bills were introduced. A handful of states have passed substantive legislation—among them California, Maine, Maryland, and Massachusetts. New studies on the impacts of chemicals used in high-tech products, on improvements in equipment design, manufacturing, disposal, and recycling appear almost daily. These topics have been the subject of intense debate on all sides of the Atlantic and the Pacific. Yet an enormous gap remains between what professionals and general high-tech consumers know about the hazards posed by e-waste and the environmental impacts of high-tech manufacturing, let alone the importance of solving these problems. I hope this book will help narrow this gap. For it seems to me that without this understanding we will continue to behave as if high-tech products exist in some kind of cyberuniverse, one that has little to do with the air we actually breathe, the water we drink, the food we eat, or our children's health.

The policies being formulated to deal with e-waste would not be under discussion in Brussels or Beijing or Washington, DC, if it were not for years of work, first by environmental and consumer advocates and then by legislators and business leaders who understand that the long-term sustainability of both industry and communities depends on making some important changes. As an environmental issue e-waste may lack the charisma of endangered species, ancient forests, and wilderness, but the push to put e-waste onto policy makers' agendas has similarly come from the grassroots—from concerned citizens and savvy NGOs in the United States, Europe, Asia, and elsewhere around the world.

The issue of e-waste has brought together activists from Hong Kong, India, London, California, the Philippines, the Netherlands, Texas, Wisconsin, and Seattle, with academics and researchers from China, Sweden, New York, and Tokyo, local and national government officials from around the world, and with executives from the world's leading high-tech manufacturers, retailers, and recycling and mining companies. There are tensions and great disagreements between environmental advocates and those representing industry and government, and between companies with very different corporate cultures, but this is by no means a story of good guys versus bad guys. It's more complicated than that.

I've been to half a dozen or more conferences on electronics recycling and related environmental issues since 2002, each attended by hundreds of industry professionals but by only a small number of environmental advocates. Without prodding from the environmental community, however, I don't think that any of the changes now taking place would be happening. And it's a charming irony that none of this global activity—on any side of the environmental activist or industry and government equation—would be possible or as effective without the aid of high technology itself.

In the conclusion of his book *Enough*, Bill McKibben lists what a number of influential thinkers consider to be the most significant innovations of the twentieth century. The two McKibben himself selects are nonviolence and wilderness. "Nonviolence, wilderness—these are the opposite of catalysts," he writes. "They're technologies that act as brakes, that retard our pell-mell rush forward, that set sharp boundaries on where we're going and how we'll get there. Right now, they aren't as important as computers. But one can at least envision a world in which they might be." And he continues, "We've been told that it's impossible—that some force like evolution drives us on to More and Faster and Bigger. 'You can't stop progress.' But that's not true. We could choose to mature. That could be the new trick we share with each other, a trick as revolutionary as fire. Or even the computer."[29]

Engineering and technology alone will not pull us out of the morass of high-tech trash. They must be accompanied by a desire to curtail the use of hazardous chemicals, stop the e-waste from piling up and from infiltrating the landscape, the atmosphere, the world's wildlife, and our bodies.

If we change our culture of instant obsolescence, our penchant for "More and Faster and Bigger," and our habit of ignoring the health and environmental impacts of manufacture until they have taken their toll, or our habit of tossing trash over the backyard fence in the high-tech arena, there will still be commerce, intellectual and scientific advancement, entertainment, electronic love letters, Listservs, digital relay of pictures, and wireless calls made to check on far-flung friends and family, but it won't be business as usual. Some changes in manufacturing, design, and disposal that will reduce the environmental impact of high-tech electronics are already under way. But a great many more need to be made. I set out to write this book with the hope of illuminating why such changes are so important—and because I believe that the more we know about the environmental and health problems caused by high-tech trash and high-tech manufacturing, and the wider this knowledge is spread, the more quickly these problems may be solved.

CHAPTER TWO

Raw Materials

Where Bits, Bytes, and the Earth's Crust Coincide

It's mid-July and the summer monsoons have begun, adding humidity to the 100-degree heat. Nobody in their right mind would be out in this mid-morning sun but I'm pulling into the Community Sports Center in Bagdad, Arizona, to meet my tour guides from the Phelps Dodge Mining Company. The two-and-a-half-hour-drive northwest from Phoenix has taken me through miles of stout saguaros and spiny Joshua trees. After the subdivisions petered out past Sun City, the Sonoran Desert reasserted itself and patches of irrigated lawn gave way to sand, cactus, mesquite, and creosote.

I've come to see the Bagdad Mine—one of the half dozen or more enormous open-pit copper mines scattered across the southern half of Arizona—because copper is an important ingredient of high-tech electronics. Arizona produces more copper than any other state—about 65 percent of the copper mined in the United States, or about 10 percent of the world's copper production. I want to get a sense of where the physical landscape and the world of bits and bytes coincide and a picture of where some of the stuff embedded in our PCs, cell phones, laptops, Palm Pilots, and other such gadgets actually comes from. It's a kind of time travel: tracing the materials of twenty-first-century technology back to their origins in the Precambrian and Cretaceous layers of the earth.