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Knowledge Review: Getting beyond Green

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Getting beyond Green: Envisioning an Industrial Reboot

Some executives and scientists are calling for a radical rethinking of chemicals, cars, farms, and our future.

BY NANCY A. NICHOLS

Illustration by Heads of State

Speaking in Boston in May 2010, Fisk Johnson, the fifth-generation family member to lead S.C. Johnson & Son Inc., the Wisconsin-based maker of consumer goods such as Pledge and Ziploc, urged his business colleagues to get off the incrementalist path. "We need disruptive progress," GreenBiz.com reports Johnson saying. "We as businesses squeeze a little bit of waste here, reduce energy use there. But are we really making fast enough progress to head off the resource crunch?"

The simple answer, of course, is no. "Even if every company on earth emulated the practices of the best companies," said Johnson, "it would not be enough."

He should know. Johnson, a Cornell University–trained engineer, led his company to a Presidential Green Chemistry Award for Greenlist, a trademarked process that the company developed to identify and evaluate the environmental footprints of its products and processes. (See www.scjohnson.com/en/commitment/focus-on/greener-products/greenlist.) The company's engineers and designers use this process to explore the trade-offs involved in removing dangerous ingredients from its products. For example, the company removed polyvinylidene chloride (PVDC) from Saran Wrap — a move that health and environmental activists applauded, but one that rendered the product less useful. Without PVDC, the plastic wrap is less clingy and less effective at containing moisture and odors.

"Today," Johnson told the packed ballroom of executives in Boston, "this product, which was around from my childhood, is almost gone. We still feel this is the right decision. However, there are [only] so many of those decisions you can make before you put yourself out of business."

Smart businesspeople like Fisk Johnson as well as environmentalists are converging on one new truth: The degree of change delivered by incremental solutions is not enough to address some critical environmental problems — including toxins in our soil, water, and air; climate change; and our dependence on fossil fuels. What's needed is transformational change that enables leaps

in policy, procedure, and the very way we do business — the kind of change necessary to move from business decisions that are environmentally correct, but that devastate product lines and profits, to decisions that deliver business value, yet don't damage the environment. In order to make progress on several critical environmental fronts, a radical rethinking of the basic building blocks of business is required, as is an entirely pragmatic eco-redesign of many products.

Perhaps a sea change in the way we think about business and the environment is already under way. A number of books have made the welcome shift from the endless rehashing of environmental threats to a new set of visionary solutions. They add up to a sort of industrial reboot that ambitiously promises to solve our most pressing environmental problems with a new set of innovations, reform even the most basic disciplines (such as chemistry), and ignite whole new industries.

Nontoxic Chemistry

It seems as though it should be common practice for companies to analyze their products and processes to determine their potential to harm the environment or human health. Yet only in the last few decades have the majority of companies begun to think about these impacts.

For the most part, materials and chemicals have traditionally been judged almost solely on their cost and performance, both in the manufacturing process and in the finished product or service. This has led to a host of environmental and health problems, including lead in paint, asbestos in homes and schools, and bisphenol A in baby bottles and water bottles.

"Of the 30,000 or so chemicals currently in common commercial use, the environmental and health impacts of only about 4 percent are routinely monitored," writes Elizabeth Grossman in her powerful book, *Chasing Molecules: Poisonous Products, Human Health, and the Promise of Green Chemistry*. "Some 75 percent have not been studied for such impacts at all."

Many chemicals persist in nature even though their usefulness — as sealants, waterproofers, flame retardants, and so on — is over.

Nor were these chemicals designed with any thought to whether they might accumulate in human blood and tissues — a now common occurrence. In her book, Grossman delivers an engaging and detailed history of the use and effects of chemicals as we most often encounter them: in the form of pollution that has spread to a wide variety of places, from mother's milk in most countries to the farthest reaches of the Arctic.

"If you are getting a Ph.D. in chemistry and you are going to make a life creating new products, you are never required to take a class in environmental science or toxicology," Grossman told me recently. Even as scientists continue to document the many adverse effects of common chemicals, the American Chemical Society, which accredits academic chemistry programs in the United States, has no requirement that chemists be educated regarding chemicals' environmental and health effects.

The green chemistry movement is out to change that. As Grossman relates it, green chemistry got its start when John Warner, a chemist at Polaroid, became interested in the possible dangers of chemical contaminants after his second child was born with a fatal birth defect. He realized that he had synthesized more than 2,500 chemicals yet had never had a class in toxicology. We have been like "monkeys typing Shakespeare," he said.

With a colleague from the U.S. Environmental Protection Agency, Paul Anastas, Warner set out with a mission: Chemicals should be safe when they are designed; no waiting until they are in products and landfills to discover their dangers. He went on to found the nation's first doctoral program in green chemistry at the University of Massachusetts at Lowell.

Many chemicals persist in nature even though their usefulness — as sealants, waterproofers, flame retardants, and so on — is over. One of the goals of green chemistry is to create molecules that break apart easily and then recombine, like the most common molecules in nature. In other words, green chemists seek to create molecules that do not endure beyond their intended use.

As Warner told Grossman, "In nature, weak molecular bonds — bonds that come together and apart again, that assemble and reassemble,

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and are reversible — dominate.... If we can learn what they do in nature, we should be able to make better, less toxic products."

In searching for a better alternative, scientists and businesspeople are looking to nature — a concept called biomimicry. Biomimicry was introduced to the broader reading audience in a seminal book of the same name published in 1997 by Janine Benyus. (See "The Thought Leader Interview: Janine Benyus," by Amy Bernstein, *s+b,* Autumn 2006.) But the book that most businesspeople will remember is *Natural Capitalism: Creating the Next Industrial Revolution,* by Paul Hawken, Amory Lovins, and L. Hunter Lovins (Little, Brown and Co., 1999). One of the most relevant ideas in the book is simple to state, but extremely difficult to execute: Make things the way nature does, in closed-loop systems that minimize or eliminate waste and toxicity.

As Grossman so convincingly explains in *Chasing Molecules,* green chemistry involves changing the established mind-set in many companies so that what goes into products won't have to be scooped out of lakes and landfills later. It involves avoiding potentially dangerous chemicals so they don't ever get into products in the first place. For example, Grossman tells the story of the winner of the 2007 Presidential Green Chemistry Award, Kaichang Li, a research scientist at Oregon State University, who developed a soy-based adhesive that is replacing the potentially hazardous formaldehyde-based adhesive used in plywood and veneer products. The new safer alternative, called PureBond, was developed to mimic the workings of the liquid protein that mussels use to attach themselves to rocks. It costs less to make than formaldehyde-based adhesive.

Farming Up

Another example of biomimicry is the vertical farm, in which crops are grown in a water and nutrient mix (hydroponics) or in a nutrient-laden mist (aeroponics) in specially constructed, sunlight-maximizing high-rise buildings. As proposed by Columbia University professor Dickson Despommier, a vertical farm would behave like a functional ecosystem in which waste is recycled and the water used is recaptured by dehumidification and recycled in a closed-loop system.

Despommier estimates that by the year 2050, 80 percent of the global population will live in cities. But climate change and a dearth of farmland could make it increasingly difficult to grow enough food for urban dwellers, and the environmental and financial costs of shipping food great distances are already apparent. The vertical farm, which could produce the equivalent of as many as 20 traditional soil-based acres per floor depending on the crop, could be a breakthrough solution for providing food to ever-growing and ever-denser urban populations. (Designs for a prototypical vertical farm can be seen at www.verticalfarm.com.)

In his book *The Vertical Farm: Feeding Ourselves and the World in the 21st Century,* Despommier lists a host of advantages to growing food in city high-rises. Crops would be protected from weather and the vagaries of climate change. The use of fossil fuels would be reduced. The agricultural runoff of pesticides, herbicides, and fertilizers would be eliminated, and the land now used for farming and other purposes could be used less intensively, allowing the soil and nearby rivers to recuperate.

Indoor farming lies at the root of a concept for a chic new food

mart developed as a summer project by a team of graduate students at Singularity University, which was cofounded by futurist Ray Kurzweil. At Denmark's Nordic Exceptional Trendshop 2010, the students promoted their concept for a self-serve grocery store/indoor farm/café, in which food is grown on shelves that line the wall and fish are farmed in a stream that runs underneath the store and is visible beneath a glass floor. If it can get funding, the team plans to collaborate with NASA on robotics, explore genetically modified food, and integrate new advances in LED lighting into the facility. (See http://agropolisfarm.com.)

Of course, enticing people to buy and eat food grown indoors will require that it live up to the popular paradigm of healthy food — pastoral farms and harvests rich with color and smell. "Paradigms hold immense sway over our minds," Amory Lovins, chairman and chief scientist of the Rocky Mountain Institute and coauthor of *Natural Capitalism,* said in a recent interview in the *MIT Sloan Management Review*. "We all struggle with this, but as…[Polaroid founder] Edwin Land used to say, 'People who seem to have had a new idea have often simply stopped having an old idea.' That's the hard part."

Electric Cars, Smart Grids

Consider the paradigmatic car. *Reinventing the Automobile: Personal Urban Mobility for the 21st Century,* by the late William J. Mitchell, an MIT professor, and Christopher E. Borroni-Bird and Lawrence D. Burns, two General Motors executives, argues that the 120-year-old conceptual model of the automobile is no longer tenable. Emissions, congestion, rising gas prices, and probable fuel shortages are all problems that can be traced back to cars as they are currently conceived. (See "The Thought Leader Interview: Lawrence Burns," by Scott Corwin and Rob Norton, *s+b,* Autumn 2010.)

The automobile, as the authors point out, was created in the vein of an even older tradition — the horse and carriage. There is no law dictating that the engine be in the front of the car; the fact that horses pulled carriages was simply too strong an image for early inventors to ignore. They also calculated their new invention's performance in terms of "horse power."

In this thoughtful and beautifully designed book, the authors make a compelling case for a new approach to fitting automobiles into society: not as stand-alone cars, but as "personal urban mobility systems" that are fueled by electricity and hydrogen, and that function as nodes in a connected transportation network in which they communicate with one another wirelessly, thereby avoiding crashes and traffic jams.

Moreover, the authors assert that these new vehicles must appear completely different from the car. "Future vehicles must have the look and feel of a new and desirable kind of product," they write. "Nobody thinks of an iPod as a shrunken home stereo system, and nobody should be left with the impression that an intelligent electric-drive vehicle is a dull but worthy 'econo-box.'" To that end, they propose entirely new designs for vehicles. The driver may enter from the front, control the motion with a joystick, and slide the vehicle sideways to park it like a book on a shelf.

"Future vehicles must have the look and feel of a new, desirable product. Nobody thinks of an iPod as a shrunken stereo system."

The success of their design, however, is based on something else entirely: a new grid to distribute the electricity needed to power such vehicles. "During the twentieth century, industrialized nations built two kinds of massive but disconnected energy conversion systems — gasoline-powered light vehicle fleets and electric grids," write the authors. "But that situation is about to change. There is, now, an emerging convergence of electric-drive vehicle and smart-grid technologies. They are maturing within the same time frame; each will be beneficial to the efficient operation of the other; each will facilitate the large-scale deployment of the other; and they are likely to be increasingly closely integrated with one another."

In his exceptionally clear and easy-to-understand book, *Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities,* Peter Fox-Penner, the former chairman of the Cambridge, Mass.–based consulting firm the Brattle Group, argues for a new kind of utility grid that can power electric cars,

among many other things.

To describe the workings of an electric grid, Fox-Penner uses the analogy of a system of linked ponds in which all the ponds must be kept at the same level despite gushing waterfalls, heavy rains, and intermittent and unexpected water drawdowns. In the grid, electrical power is the water and digital controls run the system that keeps the "ponds" in equilibrium, avoiding the kind of service disruptions that occurred in California in 2000–01.

In most countries, the electric system is based on large, centralized sources of power generation. Fox-Penner envisions a system with many smaller sources of power and decentralized control. This new electric grid would more closely monitor supply and demand, and set flexible pricing based on how much power is being used at any one time. In addition, digital controls would allow homes and businesses to produce energy at certain hours and consume power at other times. The grid would also monitor energy use and adjust pricing to curtail demand in an effort to limit carbon emissions.

How the changeover to this new grid will occur, who will fund the massive investment necessary, and which companies will benefit are major questions in this scenario. Fox-Penner, who is both an engineer and an economist, does a good job of laying out many possible options and obstacles. "Creating a decentralized control paradigm, retooling the system for low-carbon supplies, and finding a business model that promotes much more efficiency," he writes, "…together will define the future of power."

The transition has already begun. General Electric recently teamed up with a group of venture capitalists and offered US$200 million in startup money for the best ideas for transforming the grid. (See http://challenge.ecomagination.com/ideas.) When the contest closed on September 30, 2010, it had attracted more than 3,500 ideas from around the globe and registered almost 74,000 voters.

General Electric and its partners will decide who gets the money, but a startup company named Solar Roadways won the popular vote for its concept of roads that recharge electric vehicles as they drive. Another top contender is Nextek Power Systems, whose popularity may be due in part to an engaging promotional video that makes a case for direct-current grids as a way to connect renewable energy sources and high-tech devices without as much wasted power. (See it at http://vimeo.com/15004808.)

Progress and Profits

The New Polymath: Profiles in Compound-technology Innovations, by Vinnie Mirchandani, a blogger and former Gartner analyst, is a book that seems to be about everything and nothing at the same time. In it, Mirchandani uses examples from dozens of companies to argue that we will soon be experiencing a renaissance of new technologies and sustainability that will meld together and yield new ways of living and working. Although the book lacks a compelling logical order and it is often hard to understand how the dif-

Industrial Reboot Resources

Works mentioned in this review.

Elizabeth Grossman, *Chasing Molecules: Poisonous Products, Human Health, and the Promise of Green Chemistry* (Island Press/Shearwater Books, 2009)

Dickson Despommier, *The Vertical Farm: Feeding Ourselves and the World in the 21st Century* (Thomas Dunne Books, 2010)

William J. Mitchell, Christopher E. Borroni-Bird, and Lawrence D. Burns, *Reinventing the Automobile: Personal Urban Mobility for the 21st Century* (MIT Press, 2010)

Peter Fox-Penner, *Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities* (Island Press, 2010)

Vinnie Mirchandani, *The New Polymath: Profiles in Compound-technology Innovations* (Wiley, 2010)

Matthew E. Kahn, *Climatopolis: How Our Cities Will Thrive in a Hotter Future* (Basic Books, 2010)

ferent stories are connected, it does get one thing right: Everything is going to have to change at once if this renaissance is to be realized. The same is true for a successful industrial reboot.

The electric grid will have to change to support personal mobility units. These vehicles will need to be built without that "new car" smell — which some contend is emitted by chemicals that are harmful to our health — possibly using the kinds of green chemistry that Grossman tells us about in her book. We will have to change our notion of how and where food is grown, and that will require new notions about how we power our cities and use and reuse water, among many other things.

If the comprehensive interconnection of all this seems too daunting, consider *Climatopolis: How Our Cities Will Thrive in a Hotter Future,* by Matthew E. Kahn, an urban and environmental economist at UCLA. This book, which looks at how cities will cope with climate change, is remarkable for its sheer pragmatic optimism. (For a practical guide to "green city" opportunities, see "Reinventing the City to Combat Climate Change," by Nick Pennell, Sartaz Ahmed, and Stefan Henningsson, *s+b,* Autumn 2010.)

Those who follow the news have already had their fill of stories about the worst possible environmental outcomes. Kahn readily admits the potential dangers we face, but he stands out both for his commonsense approach to looking at the problems and for his hopefulness. For instance, when he examines the Great Chicago Fire of 1871, he sees the development and growth that occurred in its wake and how the fire eventually made the city stronger. Those trained in economics will see that he has been influenced by Joseph Schumpeter's notion of creative destruction.

Although he acknowledges that capitalism and global industrial expansion have contributed to climate change, Kahn holds firm in his belief that it is also capitalism that will save us. He reminds us that a key theme in modern economics is that our scarcest resource is not natural capital, but human ingenuity of the kind that fueled the original Renaissance — think Leonardo da Vinci and Galileo. With the billions of educated, ambitious individuals in the workforce today, Kahn reasons, the best adaptations and innovations ought to be pretty good. As he says, "A small cadre of forward-looking entrepreneurs will be ready to get rich selling the next generation of products that will help us adapt."

He's probably right. The entrepreneurs and companies that undertake the industrial reboot will participate in the creation of new industries and the rebuilding of the infrastructure on which we all depend. In the end, profits remain quite a compelling reason to stave off some of our worst environmental nightmares. +

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