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The Biosphere Rules

by Gregory Unruh

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Summary. Reprint: R0802H Sustainability, defined by natural scientists as the capacity of healthy ecosystems to function indefinitely, has become a clarion call for business. Leading companies have taken high-profile steps toward achieving it: Wal-Mart, for example,... **more**

Sustainability—which natural scientists define as the capacity of healthy ecosystems to continue functioning indefinitely—has become a clarion call for business. Consider General Electric's ambitious Ecomagination project, Coca-Cola's efforts to protect water quality, Wal-Mart's attempt to reduce packaging waste, and Nike's removal of toxic chemicals from its shoes. These and other laudable efforts are steps on a road described by the aluminum giant Alcan in its 2002 corporate sustainability report: "Sustainability is not a destination. It is a continuing journey of learning and change."

Unfortunately, Alcan had it wrong. At best, the view of sustainability as an endless journey of incremental steps does a disservice to managers seeking to square economy with ecology sooner rather than later. At worst, it serves as an excuse for inaction when it comes to building a truly sustainable business.

I believe that sustainability should be not a distant, foggy goal but, rather, a real destination. This view has emerged from a search begun in the 1980s, when I was an environmental consultant hired to help clean up the toxic messes of *Fortune* 500 companies. That work inspired me to launch a long effort to discover the true basis for sustainability. After conducting hundreds of interviews with managers, scientists, engineers, academics, designers, and architects, I came to the simple conclusion that we already know exactly what sustainability on planet Earth looks like.

A perfect model, refined through billions of years of trial and error, is our planet's biosphere—defined in 1875 by the geologist Eduard Suess as "the place on earth's surface where life dwells." Researchers have only recently begun to explore how nature's technology can be emulated in the service of sustainable manufacturing and commerce. Earth's complex, self-regulating biosphere is, in essence, a brilliant operating system that has fashioned prolific life without interruption for more than 3.5 billion years. By studying the interdependent principles that collectively account for Earth's sustainability, managers can learn how to build ecologically friendly products that reduce manufacturing costs and prove highly attractive to consumers. Moreover, companies do not need to wait for a green technological revolution to implement manufacturing practices that are both sustainable and profitable. They can apply the biosphere's lessons to industrial technology today.

In this article I will describe three important biosphere rules and show how enterprising companies are adapting them for both environmental and economic gain. I mean to be descriptive rather than prescriptive; readers will need to interpret and translate nature's architecture for their own business models, and companies will obviously have to resolve numerous challenges before these rules can be fully implemented. Following the rules flies in the face of standard practice, as readers will discover, and change is always difficult. Nevertheless, companies will eventually have no choice but to adapt in a world in which the material and energy burdens of the developing economies are already straining our planet and creating volatile market conditions. As China, India, Brazil, and Russia rapidly industrialize, their added demands will force companies to develop more-sustainable manufacturing platforms. In this world, first movers that can bring their manufacturing strategies into line with the laws of nature will be the winners.

The rules for the biosphere's operating system are built upon *bio-logic*, which nature uses to assemble life and structure ecosystems. In contrast to the *industrio-logic* of human manufacturing, which assumes that largely synthetic materials should be assembled or molded into desired shapes, bio-logic builds things from the bottom up, relying on sophisticated nanotechnology to assemble organisms molecule by molecule. Powered by nothing more than rays of sunshine, nature can miraculously produce a tree or a cactus. This life-friendly process occurs silently and uses a simple palette of materials, drawn from air and water, as its manufacturing media.

Rule #1: Use a Parsimonious Palette

The elements in the periodic table, from actinium to zirconium, are the building blocks of everything we see. Astonishingly, however, out of the more than 100 elements, nature chose to use just four—carbon, hydrogen, oxygen, and nitrogen—to produce all living things. Add a little sulfur and phosphorus, and you can account for 99% of the weight of every living thing on the planet. The fourteenth-century scholastic William of Occam derived his law of parsimony from Aristotle's assertion "The more perfect a nature is, the fewer means it requires for its operation." Today we say simply "Less is more."

The biosphere's elegant simplicity is the exact opposite of the approach taken by manufacturers that readily adopt every new synthetic material, from Teflon to Kevlar, that science pumps out. The impulse is understandable. Different materials add different performance characteristics. Take a potato chip bag. Although it appears simple, the bag is actually a highly engineered sandwich of thinly sliced materials, each performing a different function. The innermost layer is a special plastic that won't react with the chips. Next to it is a layer of material that keeps out moisture.

Then comes a thin layer of metal foil to keep out sunlight. After that is a layer that accepts print for marketing messages. Clear layers on the outside keep the print from rubbing off.

A designer accustomed to using industry's nearly infinite palette of specialty materials would think it silly not to take full advantage of them. However, there is one overriding reason to emulate nature's parsimony: It makes recycling easy. (In contrast, the thin layer of metal foil in a chip bag cannot be recovered economically.) Furthermore, nature's simple palette results in products far more advanced than those produced by human industrial science. Abalones produce mother-of-pearl that is twice as tough as science's best ceramics. Spiders can spin silk that is stronger than steel yet light enough to float on the wind. Nature suggests that the potential for inventive uses of easily recycled materials is huge.

Rule # 2: Cycle Up—Virtuously

Standardization ensures that raw materials are always available to organisms; they don't have to be shipped or sorted. When an organism dies, the biosphere recovers its materials and reinserts them into its production processes. Nature repeatedly reuses these materials in evolutionary growth and development, continuously cycling them up. Up-cycling maintains the value of materials between generations of recycled product without loss of quality or performance. Down-cycling, in contrast, destroys the original value, as when a plastic computer casing is melted into a speed bump. The biosphere doesn't down-cycle materials. A dead beaver can be reincarnated as a tree, a mollusk, an eagle, or even another beaver—all high-value applications of nature's recycled materials. From the first cyanobacteria to human beings, nature has used the same materials in a virtuous cycle of increasing complexity and value, allowing the biosphere to evolve toward ever more integrated and sustainable communities of organisms.

Virtuous recycling is counterintuitive, because it relies on planned obsolescence—the bane of environmentalists. Conscientious manufacturers understandably see planned obsolescence as a vice. Designing an early demise into new products became an infamous part of Detroit's strategy to sell more cars in the 1960s and was widely condemned as wasteful. But biological obsolescence—otherwise known as death—plays a vital role in the biosphere. The unceremonious process of ushering out the old and ushering in the new allows change; without it the biosphere could not evolve. In the context of the biosphere rules, planned obsolescence can become sustainability, leading a company toward environmentally superior designs.

Rule #3: Exploit the Power of Platforms

Earth is populated by a mind-boggling 30 million to 100 million species, all of which miraculously share an underlying design. The basic architecture of life was set by the earliest multicelled organisms, more than 3 billion years ago. Since then, even though the process of evolution has made life more complex, every creature, from trilobite to human, has been a riff on nature's original design. The design is a general-purpose platform that has been leveraged over and over again to create the planet's astounding biodiversity. This strategy is so successful that life can adapt to exist anywhere on the planet, from the abyssal plains of the oceans to the peaks of Mount Everest.

Luckily for managers, industrio-logic concurs with this biosphere rule. Businesses across sectors have long exploited the power of platforms. Microsoft's Windows, for example, is a general-purpose computing platform that the company has leveraged across any number of applications, from Word to Media Player.

Manufacturing, too, appreciates platform strategies. In the automobile sector, for example, different models can use the same parts or drivetrains. But platform design in industry tends to occur at the component level, allowing parts to be swapped among product offerings. Industry needs to go below this level and scrutinize the makeup of the components themselves: The materials are a more fundamental platform on which both components and final products are built.

The Biosphere Rules in Action

The biosphere rules demonstrate their real value when they are integrated into an overall strategy to exploit the muscle of sustainable product platforms. If a company extends this strategy across a product line, relative costs decline as the scale of production grows, fostering profitable returns on investments in sustainability. Economic sustainability ensures environmental sustainability.

To date, few companies have built sustainable manufacturing systems that conform to all three of the rules. Shaw Industries, a Berkshire Hathaway company, has come close.

Shaw produces carpet tile, an industrial flooring that is installed in office buildings around the world. In 1999, when confronted by growing environmental concern over carpet waste (more than 95% of old carpet is ripped up and dumped in landfills) and the specter of higher raw-materials costs, Shaw embarked on a major initiative to rethink its business and create what it calls "the carpet of the twenty-first century."

Carpet tile like Shaw's is composed of the backing, which holds the carpet flat, and the face fiber, which creates the soft walking surface. Until 1995 Shaw produced a branded backing made from PVC plastic. But PVC is potentially toxic and difficult to recycle. So, at substantial expense, the company went in search of a more sustainable solution.

Acting on an intuitive understanding of sustainability, Shaw recognized the need for a simple palette of nontoxic materials for its product. It also made virtuous recycling a goal. Its choice of Nylon 6 face fiber, branded Eco Solution Q, and polyolefin backing, called EcoWorx, gave Shaw materials that could be cycled from high-value application to high-value application without ever losing performance or functionality. The company developed an integrated production system that could take carpet at the end of its useful life, separate the backing, grind it up, and put it right back into the manufacturing process. Coming out at the other end was brand-new carpet tile. The Environmental Protection Agency recognized EcoWorx with its Presidential Green Chemistry Challenge Award in 2003.

> **Shaw Industries can look to a future when the skyscrapers of the world's cities, rather than the wellheads of Saudi Arabia, will supply its raw materials.**

Shaw's sustainable product platform has also helped free the company from the vagaries of the raw-materials markets that plague the industry. The primary input for both the backing and the fiber of most carpets is petroleum. When Shaw began its efforts, oil was at $19 a barrel. With oil prices at this writing nearly five times that, the company seems like a savvy visionary. Shaw can look to a future when the skyscrapers of the world's cities, rather than the wellheads of Saudi Arabia, will supply its raw materials.

Phasing In the Biosphere Rules

Shaw's accomplishments were by no means easy, though they won accolades and produced long-run benefits. Senior executives made a $2 million bet on an unproven technology that threatened to render their state-of-the-art production facilities obsolete. They did so without concrete evidence that customers would value sustainability in carpeting. Ultimately, Shaw's leaders mustered the conviction and faith required to build a sustainable product platform that would create future competitive advantage. Not all companies are willing to make such a bet. Because a shift to sustainable manufacturing is dramatic, managers are likely to confront organizational rigidities as they try to implement the biosphere rules.

Those rules can, however, be phased in over time in a way that limits disruption. Again, there is a biospheric analog for this process. In nature, new ecosystems—pine forests, alpine meadows—don't spring up fully formed. They develop through a gradual process known as succession, in which colonizing species alter the local environment and make it hospitable to a larger, more diverse community of organisms. The biosphere rules can create an organizational environment hospitable to subsequent steps. Phasing them in minimizes costs and permits an orderly transition. More important, it can create near-term wins that provide motivation for continued efforts.

Step 1: Think fewer materials.

The first step for managers wishing to implement the biosphere rules is to rethink their sourcing strategies and dramatically simplify the number and types of materials used in their company's production. This step is fundamental if the company hopes to recycle cost-effectively.

When the furniture manufacturer Herman Miller examined the makeup of its leading Aeron desk chair, it found more than 200 components. McDonough Braungart Design Chemistry (MBDC)—a company founded by the sustainability advocates William McDonough and Michael Braungart—reviewed the chair's chemistry and discovered that the 200 components were made from more than 800 chemical compounds. Although the use of diverse materials is standard industry practice, inputs on this scale confound moves toward sustainability. Herman Miller parlayed this knowledge into the subsequent design of its award-winning Mirra desk chair, released in 2003, whose dramatically simplified materials palette is 96% recyclable.

How should an organization start to rethink its materials choices? A number of companies use toxic-materials screens to weed environmentally suspect components out of their supply chains. These screens range from a simple list of prohibited chemicals sent to a company's suppliers to sophisticated protocols calling for laboratory analysis of a product's inputs. The screening process requires companies to collect detailed information from their suppliers about the chemicals in their products and then to evaluate the impact of those chemicals on environmental and human health. Suspect materials are tagged for elimination. The screens can be quite restrictive, as the Swiss chemical giant Ciba-Geigy learned in 1995. When Ciba's 1,600 chemical dyes were run through an MBDC screen, only 16 passed the test.

Though toxic-materials screens make sense, they work backward, negatively eliminating risky materials rather than positively selecting the best ones. Trying to incrementally weed out waste and toxins, whether through eco-efficiency or screening, is too slow a road; managers may find themselves substituting analysis for action. Instead companies can move straight toward a parsimonious palette by going beyond traditional sourcing criteria such as performance and aesthetics. Biosphere rule #2 provides two additional criteria, one physical and one economic.

Materials must be physically capable of being up-cycled.

Not all materials are. The Nylon 6 in Shaw's carpet, for example, can be up-cycled, but its closest relative, Nylon 6,6, can't. Both are used in the carpet industry, but only the former is turned back into high-value carpet fiber. If it is recycled at all, Nylon 6,6 is melted down for use in much-lower-value products such as plastic lumber and automobile glove boxes—just a stop on its eventual way to the dump.

Materials recycling must be cost-effective.

Is it cheaper to buy new inputs on the open market or to use reprocessed materials? If reclaimed materials prove to be cheaper, you have found a virtuous winner. Up to 75% of steel and more than 50% of aluminum are recycled, mostly because doing so uses a fraction of the energy needed to produce virgin metal.

Rethink "Reduce, Reuse, Recycle"

The traditional mantra for environmentally responsible materials management has been "Reduce, reuse, recycle," ...

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Step 2: Rethink design.

When engineers are faced with a new design challenge, they usually ask, What is the best specialty material for this application? But with a limited materials palette the question becomes, What design will meet our product specifications using our existing materials? Or, How can we engineer a cool new product made from our limited materials? Integrating this kind of thinking into product design means beginning at the end.

To make virtuous recycling work, managers should plan at the beginning of design for the end of their product's useful life. In nature, bacteria will recycle the carcass of a rabbit because it has lots of energy and food value left in it. Environmentally conscious managers, in contrast, have tried to minimize the materials in their products in the name of eco-efficiency. This makes sense if the products are to be thrown away when customers are finished with them, but it can be insidious if you're trying to recover the materials economically.

Consider the story of Polyamid 2000. With nearly 5 billion pounds of carpet waste going to landfills each year, and less than 5% of waste carpet being recycled in the 1990s, carpet manufacturers found themselves under fire from NGOs and government officials. In response to the criticism, the industry turned to Polyamid 2000's monstrous facility, housed in a Communist-era manufacturing plant in the former East Germany, which was designed to recycle nylon face fiber from old carpet. The face fiber was attractive because it was the most valuable part of a carpet and could be chemically broken down and turned into fresh material that was as good as new. Because the process used less energy than making nylon from raw-materials stocks, it was also expected to be profitable.

The Polyamid facility was an industrial marvel, relying on a highly efficient assembly-line approach. Waste carpet was trucked in, cleaned, scanned, and then transported on overhead conveyors to the chemical equipment that broke the fiber down into raw materials. The facility was expected to extract 20 million pounds of new Nylon 6 from more than 250 million pounds of waste carpet each year. But within three years it had been shuttered.

How could such a promising green solution fail so spectacularly? According to a Polyamid technical manager, “The content of nylon in European waste carpets is less than expected and decreases every year.” Whereas American carpets are made with 45% nylon fiber, European carpet manufacturers had reduced nylon content to 25%. This saved raw materials but made it uneconomical to collect and recycle carpet waste. Well-meaning environmental strategy starved Polyamid to death.

Manufacturers can avoid the same fate by cycling up. They should design recovery value in at the outset.

Step 3: Think scale economies.

A parsimonious palette and a virtuous recycling process can in effect establish sustainable platforms for entire product lines. In 2005 the outdoor gear retailer Patagonia announced just such a platform strategy—the Common Threads Garment Recycling program—in partnership with Teijin, a Japanese fabric manufacturer. Teijin virtuously recycles Patagonia’s Capilene brand performance underwear into second-generation polyester fibers that Patagonia reuses in the following season’s clothing. Patagonia has extended the platform beyond underwear to include fleece garments. As other companies follow suit, leveraging standard materials and cyclic production systems for new and existing products, they foster the economies of scope and scale that drive lasting operational profitability.

Following the biosphere rules can compound cost savings. First, simplifying a materials palette for sustainability reasons reduces supply-chain complexity, shrinks the vendor count, generates volume discounts, and improves the service of suppliers as more business is sent their way. Interface Fabric, for instance, has found savings of $300,000 a year from palette simplification alone.

Second, companies may discover that cost savings emerge from the virtuous recycling of materials. For example, Patagonia's energy costs to recycle the materials in its underwear are 76% below those for virgin sourcing. Shaw Industries found that the virtuous recycling of Nylon 6 requires 20% less energy and 50% less water than virgin input requires. As Shaw expands its vertically integrated production process to new products, it can spread its investments and processing advantage over increasing output. In 2006 the company announced an extension of its carpet-tile platform to broadloom carpet, which accounts for 70% of the entire carpeting market. Such leveraging of a sustainable-product platform can create long-term competitive advantages.

Clearly, savings are not automatic or uniform across companies. They require disruptive changes and investment based on a vision of a greener future. Ultimate profitability depends on how effectively companies execute the biosphere rules—a likely source of competitive differentiation in the future.

Step 4: Rethink the buyer-supplier relationship.

Companies will have to manage the transition period as a product goes from 100% virgin materials to nearly 100% virtuously recycled materials. That will require finding ways to profitably recover products installed in customers' homes, garages, and office buildings and put them back into the production process. Following the biosphere rules will radically change the traditional buyer-supplier relationship: Customers will come to play a dual role as buyers of the company's products and suppliers of its input materials, adding a new twist to the adage "Stay close to your customers." It will require managers to rethink sourcing, marketing, sales, and service.

For example, how will you forecast future supplies of input materials when the return rate is tied to your customers' next decision to buy? That depends in part on the life cycle of your product. Patagonia can expect the raw materials in its underwear to cycle back to the company in about 18 months. Shaw, however, has to wait three to seven years for the life cycle of carpeting to run its course. Companies will thus need to anticipate return rates and may even find themselves managing product life cycles—perhaps providing incentives for customers to prematurely upgrade to the newest model. As in the biosphere, virtuous planned obsolescence will become a sustainability requirement.

Managers will also face the complex issue of reverse logistics—getting the used product back to the factory for reprocessing. Some companies are coming up with clever solutions. In Patagonia's world, for example, garbage cans morph into mailboxes: The company urges customers to mail back their used (and, it is hoped, clean) underwear or drop it off at retail outlets. This is not an option for Shaw's carpets, so it becomes important to align the pickup of used product with the delivery of new, to be sure that trucks are full both leaving and returning to the factory.

Managers might see the effort required to manage planned obsolescence and reverse logistics as a disincentive for adopting the biosphere rules, but that would be shortsighted. Companies spend large amounts of money on advertising and marketing to persuade customers to contact them—so there is value in a customer's calling you to say she'd like to have you pick up her old product. Indeed, an astute salesperson would see this as a blazing-hot sales lead. If through planned obsolescence a company could convert a percentage of its customers into repeat buyers, it could make important financial gains. And, its critics notwithstanding, planned obsolescence can also conceivably produce environmental gains. Faster product cycles will bring nextgeneration products that usually perform better and are environmentally superior to their predecessors. A refrigerator today, for example, is bigger and 75% more energy-efficient than it was two decades ago, but it costs 50% less. Applying the biosphere rules can rapidly reincarnate materials into more-efficient products, further increasing sustainability gains.• • •

Sustainability is, in the end, nature's best secret. By reusing the same materials in an ever compounding cycle of evolutionary growth, the biosphere has sustained itself on planet Earth for billions of years. With luck, following the biosphere rules may help sustain business for a billion or so.

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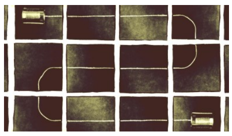

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