Biomimicry: A Way Toward Earth-Compatible Industry?
About the Imagined Economy Project

The Imagined Economy Project launched in 2014 to examine, reflect on, and promote imaginative economic development approaches in the U.S. that balance the need to earn a living with fixing longstanding economic problems like income inequality and poverty, labor downgrading, and environmental degradation. For decades, a main way of addressing these systemic challenges has been through public policy, but the limits of social welfare and regulatory policy may be heightening in an increasingly global economy and a political culture of retrenchment. Beyond policy, communities and visionaries are trying a new tactic. They are experimenting with ways of transforming economic development from the inside, and the Imagined Economy Project is motivated to understand, explore, and assess such imaginative approaches like biomimicry. In our view, biomimicry offers a comprehensive way forward for making ecosystem integrity a main value in market economies and, with time and market penetration sector by sector, it could mean creative destruction or a new industrial revolution that resolves the environmental harms incurred in the first.

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Acknowledgements

Special thanks to Megan Schuknecht of the Biomimicry Institute and Carol Thaler and Christine Hockman of Great Lakes Biomimicry who were interviewed as part of this project and also commented on drafts. Any shortcomings in analysis are the author’s. Also thanks to Dianna Snape for permission to use her photo gratis.

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Summary Overview

Biomimicry is an emerging discipline aiming to root industrial production and product innovation in nature’s own models and designs. According to proponents of biomimicry, emulating nature can get enterprise to a point of ecological soundness, drastically reducing the human footprint on the planet. Imagine producing without toxic emissions or depleting resources. Imagine consuming without producing trash or contaminating the environment. That is exactly the way nature does it and the way humans could do it if they adopted biomimicry.

In this report, the Imagined Economy Project explores the concept and practice of biomimicry with the aim of assessing how it might get us to an ecologically-sensitive green economy, particularly in the United States. Reflections are based on interviews with the Biomimicry Institute and Great Lakes Biomimicry, as well as secondary sources. The main conclusion is that biomimicry holds promise for “changing the game,” but that outcome has a very long time horizon and is not without challenges or limits for biomimicry advocates to confront.

The Strengths of Biomimicry. The report points out several encouraging aspects of biomimicry. Its origins as a named and organized approach began in 1997, with the publication of the book *Biomimicry: Innovation Inspired by Nature* by Janine Benyus. Since then, it has remained a small but growing trend, priming itself for continued growth. Since 1997:

- Multiple products have come to market or are in product development, and some of these offer significant energy efficiencies, reduced emissions from manufacturing, carbon sequestration capacities, and the elimination or minimization of toxicities.
- Biomimicry advocacy organizations operate in fifteen states to increase the general awareness of biomimicry as well as facilitate business applications.
- The University of Akron and Arizona State University established degree programs, and the Minneapolis College of Art and Design offers a biomimicry-heavy sustainable design curriculum.

If biomimicry continues to take hold, it could yield a sort of “creative destruction” making ecological sensitivity internal to corporations, rather than something to externalize or pass onto governments, consumers, and communities. This new kind of industry would be geared to:

1. *Closing the Loop*- indefinite materials reuse or return to nature instead of tossing to landfills.
3. *Local Attunement*- designing within the opportunities and limits of places.
4. *Product/Process Obsolescence*- replacing toxic or wasteful products or processes with sustainable ones.
**Limits and Challenges.** Of course, biomimicry is a new field and not yet at the point of reorienting economic development around those four principles. Actualizing such a change will take many decades and will only be conceivable through breakthrough innovations becoming commercially viable. Breakthrough innovations, like a decomposable alternative to plastic as just one example, are what will permit additional breakthroughs, in other words. Such innovation is likely to require advances not only in products, materials, and technologies but also in science itself.

In these early stages, there are limits to biomimicry’s promise beyond not-yet-existing technology. Certain critics are concerned that the environmental ethic contained in Janine Benyus’ formulation of biomimicry might be watered down as the discipline develops and new practitioners begin to adopt it in their own firms or fields. It is possible to use biomimicry or nature’s designs without also committing to closed loop materials or processes, whole system thinking, or the place-based orientation. In fact, there are multiple examples of biomimicry being used without ecological components.

**Remedies.** Maintaining a strong and clear ethical message is probably the most important way for biomimicry advocates to address these limits. By discussing biomimicry as wound up with environmental problem solving, students, professionals, and the general public will perceive and apply it in that way, as well as continue to shape it in that way. Government efforts to incentivize biomimicry are likely to be key to its growth and market penetration, so public subsidy programs that give preference to biomimicry as environmental problem-solving are urgent. As time goes on and breakthrough innovations become commercially viable, the environmental benefits of biomimicry should build exponentially, and the capacity for green impacts should also grow.

The consensus continues to build that the earth’s systems are suffering at the hands of our economy. More and more people, businesses, and institutions will be looking for serious solutions in the coming years. Biomimicry is a highly compelling approach when overlaid with a solid environmental ethic, offering promise as a far-reaching and possibly economy-wide solution to mistreatment of the earth, its resources, and its organisms. In the view of the Imagined Economy Project, the advance of biomimicry is a welcome addition to the economic development toolkit and, in particular, green-oriented biomimicry should be prioritized, supported, and incentivized more widely.
Introduction

Our market economy permits a seemingly unprecedented material richness, but the price is ecological degradation that may be approaching the tipping point for life on earth. The coming centuries are likely to involve considerably less biodiversity. By 2100, the world might have lost between one-half and two-thirds of existing species, due to varied causes like land development, deforestation, desertification, pesticide and chemical contamination of soil and water, and climate change. Continued temperature rise could make half the planet uninhabitable by 2300. And, at current rates of sea level rise, about 33% of coastal and wetland land mass could be lost in the next 100 years, according to the Climate Institute. Organisms that survive may do so in a continually precarious position, much like today’s honeybees, butterflies, and other pollinators whose declines affect plants and other species—like humans—that depend on them.

Biomimicry may offer a way to address this ecological doomsday by providing an action plan for making global enterprise compatible with the survival of earth’s ecosystems. As an emerging discipline, it operates on the premise that basing products, processes, and systems on the evolutionary designs of the natural world would go far in reducing the toll of continued economic growth and development. This is because nature’s organisms have evolved to innovate or adapt within their ecosystems in ways that do not harm them. In nature, of course, placing undue pressure on the environment is counterproductive and self-destructive. Biomimicry leads people to take cues from nature on ecologically-compatible design. With a 3.8 billion year tenure on earth, nature has probably confronted and already solved the sorts of design problems that confound human innovation. As Megan Schuknecht of the Biomimicry Institute stated in an interview, “All of the lessons are right there in front of us to learn from.”

This report is the first in a two-part series exploring biomimicry as a promising discipline for corporations/entrepreneurs, governments, scientists, and other leaders understanding that now is the time to think differently about how humans interact with the planet. As the first in the series, this report is a brief introduction to biomimicry, aiming to define it, demonstrate a few of its applications, and consider how broad-scale application could change the game in profound ways.

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1 Haydn Washington 2015. *Demystifying Sustainability: Towards Real Solutions*. New York: Routledge, p. 72. Projecting the rate of species loss is somewhat fraught, dependent upon assumptions and incomplete knowledge of the true number of species on the earth. Statistician Bjorn Lomborg, in his 2001 book *The Skeptical Environmentalist: Measuring the Real State of the World* (Cambridge: Cambridge University Press, p.) says the rate of loss is more likely to be 1.4% over 100 years, making species extinction “not a catastrophe but a problem.” While Lomborg’s findings are heavily criticized by experts in the natural sciences, it is worth mentioning the projections may overstate or, alternatively, even underestimate the scope of the problem.


3 <http://www.climate.org/topics/sea-level/>

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What is Biomimicry?

Biomimicry is an approach to human engineering and innovation guided by the wisdom of nature. The position of the Biomimicry Institute is that “There are amazing wins for consumers and the planet if we start looking at how nature does it. Nature has to do chemistry close its body, and you can’t do hazardous chemical reactions within your body and expect to survive.”

In other words, nature long ago solved the problem of ecologically-sensitive development, of continual innovation and invention to enhance survival without compromising the surrounding environment. Biomimicry offers human inventors the same opportunities, if only they start planning processes by asking, “What does nature do?” Take the company Calera as an example. Coral extracts calcium and carbonate from surrounding sea water to build a very hard, cement-like shell to protect itself. Calera developed a green cement by mimicking this process. To simplify, Calera sprays sea water through flue gas to be converted to carbonate; calcium in the water binds to the carbonate, and calcium carbonate forms a solid; Calera collects and dries this solid material into powder form using the waste flue gas. The process requires no fossil fuels and sequesters carbon that would otherwise pollute the atmosphere.

Janine Benyus popularized the concept of biomimicry in her 1997 book *Biomimicry: Innovation Inspired by Nature*. She characterizes natural design as involving nine principles that, if adopted broadly by industry, would go far in bringing human enterprise back to harmony with nature.

Scientific and business applications of biomimicry are gaining traction. In an interview with the American Society of Landscape Architects, Benyus said that, when she wrote her book in 1997, “The idea of looking to nature for innovation was just a faint signal in the academic literature.” The Da Vinci Index was developed in 2011 by the Fermanian Business and Economics Institute and other partners to measure trends in biomimicry patents, scholarly articles, and grants. It set 2000 as the baseline year for counting activity in biomimicry and bioinspiration, a related but broader concept. Since then, the index has surged; its 2014 score exceeded 700, an eightfold increase from benchmark, as indicated by the chart that follows on the next page.

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Figure 1: Growth in Biomimicry Patents, Research, Grants, and Grant Dollars

The United States leads the world in biomimicry research, with 25% of scholarly articles coming from the U.S. followed closely by China’s 23%. The top fields for biomimicry research include chemistry and materials science, although the Da Vinci Index also finds biomimicry-related research in physical chemistry, biomaterials, biomedical engineering, nano science, polymer science, organic chemistry, applied physics, and biotechnology. The Fermanian Business and Economics Institute predicts that, by 2030, biomimicry could account for $425 billion in U.S. GDP, 2.4 million jobs, and $65 billion saved in reduced resource depletion and pollution.

Biomimicry Awareness and Adoption

Getting biomimicry established takes awareness and promotion, and local organizations are forming with this aim in mind. Biomimicry advocacy organizations, research centers, and/ or university degree programs are present in sixteen states, with zoos, museums, schools/colleges, and professional or environmental associations offering biomimicry programming in several others. The Montana-based Biomimicry 3.8 and the Biomimicry Institute are the leading biomimicry organizations, the respective for-profit and non-profit consulting and educational organizations started by Janine Benyus and partners after the success of her 1997 book.

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8 Ibid, p. 10
9 Ibid, p. 36.
Additionally, there are sixteen biomimicry networking groups (listed at the end of this report) in various U.S. cities or regions that are part of the Biomimicry Institute’s global network. These educate the general public and interested professionals about biomimicry applications, largely through events, workshops, webinars, summits, and speakers’ bureaus. A small number actively engages in demonstration projects or does biomimicry consulting. Great Lakes Biomimicry in Northeast Ohio and Biomimicry Los Angeles facilitate the application of biomimicry by corporations or in urban problem-solving. Biomimicry Chicago, Biomimicry Oregon together with Biomimicry Puget Sound, and Biomimicry New England work on demonstration projects involving the Midwestern prairie, stormwater management, and greening the Boston Harbor, respectively.

Universities are also joining the biomimicry wave. In addition to standalone course offerings throughout the United States, there are a small number of degree programs. The University of Akron offers the world’s only biomimicry doctoral program and, recently, Arizona State University collaborated with Biomimicry 3.8 to roll out online degree programs. Each of these degree programs places students in corporate R&D departments with Akron students working in product development at GOJO, Sherwin Williams, Goodyear, Bendix Corporation, and Kimberly-Clark and ASU student projects at Herman Miller, Intel, Procter & Gamble, and Dow Corning. The Minneapolis College of Art and Design has a strong biomimicry component to its Sustainable Design degree, and students have formed biomimicry clubs at the University of Colorado at Boulder and California Polytechnic University.

There are a small number of biomimicry centers unaffiliated with the Biomimicry Institute but sharing the conservationist commitment. The Center for Bioinspiration at the San Diego Zoo works to develop “nature-inspired products, services, and processes,” says its website, and has produced classroom modules, zoo tours, internal biomimicry prototypes, and corporate innovation services. Georgia Tech started the Center for Biologically Inspired Design to educate academics and industry on natural design, referencing the work of Janine Benyus on its website.

Together, these activities help to raise awareness about biomimicry nationally and in local areas. They also facilitate its use in business.

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10 <http://bioinspiration.sandiegozoo.org/content/our-mission>
11 <http://www.cbid.gatech.edu/history.html>
What’s Possible with Biomimicry?

Velcro is often credited as the first modern product resulting from biomimicry, but nature-inspired innovations are evident in a variety of areas, many with clear green benefits. Here is just a tiny sampling of products or designs using biomimicry that seem to resolve some of the biggest environmental problems:

1. **Heating and cooling an office tower like termite mounds.**
   Council House 2 in Melbourne is an early example of building like a termite mound. Termite mounds naturally maintain a stable temperature, despite outside weather conditions. This is because the termites shape and site mounds to optimize the effects of the sun, insulate with thick walls, and make use of drafts through small holes in the walls. Like termite mounds, an entire side of Council House 2 vents, and warm air is captured and directed upward to control interior temperature and cool the top exterior of the building. An air conditioning system using treated sewage water creates active cooling at those peak heat times when the termite-inspired system needs supplementation. The Melbourne City Council, owner of the building, estimates the design saves 80% in energy and 70% in water use.12

2. **Packaging made out of mushrooms.**
   Evocative is a biomaterials company trying to displace plastics through bioutilization. So far, it has found success with Restore™ Mushroom® Packaging, an alternative to Styrofoam. According to a company representative, Evocative uses “mycelium (mushroom “roots”) to bond together agricultural waste particles such as seed husks or plant stalks. The natural growing process happens indoors, in the dark, in less than a week. After growth and before distribution, the resulting Mushroom® Material is dried to stop the growth.”13 Ultimately, these packages biodegrade just as food matter does and actually enrich the soil, in stark contrast to styrofoam.

3. **A quieter train thanks to a beak.**
   The Japanese Shinkansen Bullet Train was rolled out in 1964, but its high speeds caused excessive noise pollution. Its original design compressed air within tunnels, causing air to expand, create pressure gradients, then ultimately boom. Engineers looked to the kingfisher, a small bird that hunts by diving beak-first into water at very high speeds with almost no sound.

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The kingfisher does this thanks to a pointed and flat beak. Creating a flatter and pointed front for the train minimized noise pollution and also improved energy efficiency by 15%.14

4. **An end to washing thanks to the lotus?**
   The German company ISPO developed Lotusan, an eco-friendly house paint that repels dirt. It is modeled after the lotus flower that stays clean due to microscopic bumps and hairs that cause water droplets to bead up and carry away dirt particles. Like the lotus flower, the surface of Lotusan paint involves tiny peaks and valleys that minimize the surface area for water and dirt, requiring much less frequent pressure-washing than conventional paint.15 Botanist William Barthlott patented the lotus inspired technology under the brand name "Lotus-Effect®" and, besides the paint, ceramic roof tiles, architectural glass, a spray for surfaces, and self-cleaning fabrics are either at market or in the works.16

5. **Potable Water from the back of a beetle.**
   A desert beetle inspired NBD Nano to prototype a self-filling water bottle. The desert beetle survives in extremely harsh conditions with almost no rainfall thanks to a shell covered in bumps. Those bumps pull dew from the air and form it into droplets that roll down the beetle’s back directly into its mouth. NBD Nano is using these principles to develop a water bottle that may collect up to three liters of water per hour. The bottles can supply potable water and, at larger scale, may have applications in irrigating greenhouses and in agriculture.17

The possibilities for new products and systems go far beyond these five examples. Imagine fabrics that never lose their integrity or color. Imagine tapes or other adhesive that stick because of intramolecular force rather than petrochemicals. Imagine fighting disease by boosting regular immune processes rather than with antibiotics, medicine, or chemotherapy. As these possibilities suggest, biomimicry can and in cases already does meet human consumption needs with fewer energy inputs, reduced toxicity, and less waste.

Equally impressive, says Janice Benyus, is that biomimicry can also be used to mitigate existing environmental problems. Already, she says, biomimicry is being used to get carbon currently in the atmosphere down into the soil, itself depleted of about half the carbon it could store. Separately,

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engineers are using biomimicry techniques to capture and store carbon in products just like the company Calera does, or are using carbon to make plastics. As this suggests, biomimicry not only forges a new future but can help clean up some of the problems human enterprise has already caused.

**How Biomimicry Could Change the Game**

Innovations in products, buildings, and processes have been the “so far” results of biomimicry, but the possibilities far exceed the sum of those parts. Biomimicry offers a framework for changing some fundamental values and assumptions underlying the market economy, values and assumptions that currently separate economic development from ecology.

As is, our economy works on the principle of negative externalities- or industry passing the costs of harms related to manufacturing or consumer products onto third parties or the population at large. By and large, negative externalities like pollution, the depletion of natural resources, or the loss of biodiversity are impossible to price, so what we pay is far less than a true accounting of our materialism. Consumer choices and government regulations are available to deal with environmental externalities, but they happen with limited information and other serious constraints, making them imperfect ways of addressing the ecological costs of human enterprise.

Biomimicry offers a different way forward whereby negative externalities no longer need to be the unavoidable price of material progress. Looking to nature provides a whole scheme for making ecological sensitivity internal to industrial production across all sectors of the economy. Instead of accepting that harms pass to society, biomimicry changes that logic. Corporations have a built in way to prevent environmental harm and, ultimately, minimize the supply of harm passing outward.

How might companies internalize responsibility to the environment and still turn a profit? Basically, it’s because biomimicry gives them a way to improve their products as well as change their playbook. Making biomimicry a main approach to R&D could introduce three game-changing plays: closing the loop, thinking in terms of (eco)system integrity, and attuning to the local. Doing this product by product, sector by sector, and process by process could bring the obsolescence of high-pollution and wasteful products and practices. In fact, through biomimicry, Janine Benyus sees the possibility of the next industrial revolution capable of fixing much of what went wrong in

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the first, if accompanied by a fundamental change of heart about humans’ place in nature.

The economy possible through biomimicry would look much different than the one we have in place. With a widespread adoption of biomimicry and principles from nature, the economy could:

→ Become a closed-loop.

Our economy is based on a “take it, make it, toss it” logic, but David Russell Schilling describes closing the loop as a “make, use, return scenario.” Nature itself is a closed loop system, having long ago solved the problem of waste. Manufacturing the way nature does could replace the toxic (mostly petro) chemical building blocks of the current consumer economy as well as harsh, polluting production processes with materials, products, and processes beneficial to other organisms (like mushroom packaging), or else capable of true rehab, re-use, or regeneration. Overall, closing the loop through ecologically-friendly materials and production techniques would help create conditions for a zero-waste economy and would challenge the mentality seeing disposability, toxic residue, and pollution as inevitable outcomes of economic development.

→ Become system-oriented.

Development typically happens without considering how that development impacts an ecosystem. Not so with biomimicry. Biomimicry is oriented to the integrity of the whole system, not just the artificial parts built for human use. The Biomimicry Institute illustrates the difference in perspective with the example of Lavasa, a planned city near Mumbai, India. Lavasa was planned to function the same way as the moist deciduous forest surrounding it. The pavement allows rainwater to permeate back into the ground, and the roofs help rainwater evaporate; roads survive storms and monsoons thanks to inspiration from anthills. What’s more, the Biomimicry Institute explained in an interview, the city is designed to capture the same amount of carbon and water and support the same amount of species diversity as the natural environment. As illustrated by Lavasa, built environments, products, and manufacturing processes designed to replace what is depleted or extracted could better balance human living standards with ecosystem viability.

→ Become locally attuned.

In nature, organisms develop survival strategies tailored to their local conditions, and the same assertion holds in biomimicry. Rather than exporting the same products and systems worldwide, biomimicry’s approach suggests the best design for one ecosystem may not be the best for another.

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19 Center for Biologically Inspired Design 2016. “Biomimicry Explained, a conversation with Janine Benyus.”  
<http://www.cbid.gatech.edu/biomimicry_defined.html>

20 http://www.awakin.org/read/view.php?id=790


<http://themodernape.com/2015/06/02/building-cities-like-forests-when-biomimicry-meets-urban-design/>
Road surfaces such as those built in monsoon-prone Lavasa, passive heating and cooling systems targeted to local climates, landscaping, architectural, and agricultural techniques mindful of the flora, fauna, and natural resource base of particular areas are all examples when designing for the local likely would likely result in energy efficiency, diminished pollution, or other goods like water capture. Localizing development could also happen in another way, through the development of 3-D printing at local “Maker Shops.” These maker shops would fabricate on site and on demand, using fibers composed of captured carbon or decomposable material, without waste, without warehousing, and requiring no shipping. Relocalizing the economy through biomimicry has all the benefits of typical “buy local” campaigns, with added benefits of the closed loop and systems-orientation that would make the materials, components, and products circulating in the local market restorative and useful for other organisms.

→ Make high footprint products and processes obsolete.

The acceleration of biomimicry could make multitudes of harmful products and their industries a thing of the past. More architecture like Council House 2, for instance, could reduce the need for ozone-depleting refrigerants, such as those used in air conditioning; cement from Calera could replace standard cement whose manufacture is a leading source of carbon emissions. Such disruptive innovation wouldn’t stop with end-products, since the broad-scale application of biomimicry could also change the mix of energy inputs, materials, and processes used in manufacturing and even push science itself. In 2010, Biomimicry 3.8 joined with the Babcock Institute for Green Chemistry to advance a new kind of chemistry without the toxic solvents, extreme heat, and high pressure typical of mainstream chemistry. Beyond products and processes, biomimicry may even curtail consumerism itself if high-pollution products could be replaced by low-pollution ones, or if products become more durable, long-lasting, and re-useable, said the Biomimicry Institute. The economy could contract.

It may be possible to get to this type of “creative destruction-” that is, the replacement of inferior products, processes, industries- without biomimicry. But, the important thing to note is that biomimicry’s nod to nature- its basic question “What does nature do?-” gives an overarching approach as well numerous examples of tested technologies for corporations to close the loop, think of the whole ecosystem, and be locally attuned. There is no need to wait, or find some as-yet unavailable framework(s) for getting to those desired outcomes that, taken together, might add up to creative destruction.

Some Challenges, Limits, and Partial Remedies

Biomimicry is an emerging discipline, in very early stages. It is aspirational, explained the Biomimicry Institute, with its spread dependent on continuing advances in science, technology, and

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discovery as well as commitment to its environmental ethos. Clearly, changing the game through biomimicry is a very long term proposition, as was the century-long American Industrial Revolution.

The long time horizon means that biomimicry, even if the best case scenario of economy-wide creative destruction holds, is not assured to materialize quickly enough to beat a catastrophic heat-up or a “sixth extinction.”\(^{26}\) Also, biomimicry has not yet penetrated markets in any big way and also operates without certain technologies that would permit us to know its “true” results. Can it produce the amount of energy savings and human/wildlife equilibrium needed for planetary health, especially given continued growth in human consumption? That is unknown.

The writer Richard Smith is skeptical that environmental conservation can ever be made compatible with profit making.\(^{27}\) A biomimicry that has advanced through breakthrough technologies may be sufficiently different than “green capitalism” approaches like cap and trade, carbon taxing, consumer labeling, and green manufacturing given its basis in evolutionary biology.

Still, there are some voices wondering whether biomimicry can maintain its environmental underpinning, especially as it spreads outside of the main biomimicry advocacy organizations. Biomimicry maintains the human/nature dichotomy, notes the philosopher Freya Matthews, with nature still understood in terms of what it offers humans in their drive for material well-being.\(^{28}\) That nature is interpreted with very human purposes in mind leaves biomimicry open to a watering down of its environmental ethic, say Vincent Blok and Bart Gremmen. Depending on purposes or values, human inventors may use biomimicry and models from nature merely to improve technology rather than better fit technologies into ecology\(^{29}\) or let nature place limits on human lifeways.\(^{30}\)

There are certainly many examples of biomimicry that do not push that environmental envelope, or pull together those disparate elements that would “change the game.” The scholars Marshall and Lozeva site biomimetic surveillance cameras, space craft, and unmanned defense machinery, robotics, and artificial intelligence as some of the outputs of biomimicry research

\(^{26}\) The sixth extinction is the name of the possible mass extinction event that some scientists stay is happening currently. For an overview of the scientific evidence, see Elizabeth Kolbert 2014. The Sixth Extinction: An Unnatural History. New York: Henry Holt & Company.

\(^{27}\) Smith argues that green capitalism has yielded efficiency gains but these have been undermined because they have spurred economic growth instead of contraction, as well as attempts to spin unsustainable practices as sustainable. His position is that the planet cannot survive without contraction, and a very significant contraction, that is against business interest. His solution is an untenable one, basically a global socialism that forces the demise of various sectors and restricts the economy. See Richard Smith 2014. “Green Capitalism: The God that Failed,” Truthout <http://www.truth-out.org/news/item/21060-green-capitalism-the-god-that-failed>


Matthews argues biomimicry could correct this- and this is a simplification of her argument- by incorporating the notion of synergy, or the idea that nature expects something functional from humans (besides low or no impact development) just as we expect things functional from nature.


In the article, the authors reference Harvard University’s Kavli Institute for Bionano Science and Technology as form of biomimicry that does not emphasize ecological benefits, instead seeing mimicry of nature as a way to enhance performance.

\(^{30}\) Freya Matthews 2011a.
disconnected from any environmental ethic. At the other end, Freya Matthews sees the possibility of biomimetic design creating ”solar cities that photosynthesize and could replace forests; industrial plants that purify or reticulate water (that) may take the place of wetlands.” In those theoretical scenarios, inspiration from nature could result in a world with built environments taking over for nature, where life could be sustained even if ecosystems were destroyed.

Biomimicry also transforms nature, claim Jesse Goldstein and Elizabeth Johnson, by turning it into intellectual property and potentially bringing more organisms into labs than ever happens in the current economy. Some measure of raw material extraction, land clearance, and disruption to ecosystems are unavoidable in any development system, including biomimicry. The company Calera, for instance, uses sea water to cause the chemical reaction leading to its green cement. While this results in a much more climate-friendly product, it requires removal of sea water as well as disturbance of any organisms or microorganisms in that water. The urban planning project Lavasa requires trees to be chopped down and roads to be built, producing some collateral damage. In other words, biomimicry can’t erase the human footprint completely, or perfectly reconcile the dilemmas of growing consumption, extraction, and overpopulation. There are also instances of harm in nature, so it is important to recognize that natural designs do not automatically produce earth-compatible or life-enhancing innovations.

**Existing and Possible Remedies**

If there are broad-scale alternatives to biomimicry that resolve each of these challenges, the critics have not identified them. Instead, what may appear as weaknesses from the perspective of social criticism may be advantages in the early stages of practice. Biomimicry doesn’t depend on sweeping cultural change or a mass opt-out of consumerism or capitalism to get going. It can begin working on the problem of changing the game within the existing economy. It invites major corporations into the project of change in ways that meet their needs for continued product and process innovation, as well as help them fulfill a growing internal sense of corporate responsibility for the environment. Moreover, biomimicry’s current formulation does not preclude eventual cultural change, or even shifts in the economic structure. Over time, such outcomes could result, especially if fewer products are needed to sustain life, if consumers come to act to preserve biodiversity, or if new producer groups get involved to expand biomimicry through something other than profit-motive. As with anything, reflection and learning will be part of biomimicry’s maturation; there will be unforeseen consequences, and biomimicry may adjust or even be made to adjust through regulations.

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34 Blok and Gremmen 2016.
36 These might include multi-stakeholder cooperatives, public corporations, or nonprofit organizations.
There may already be solutions to some of biomimicry’s limits or inconsistencies. Live animal research could be minimized by borrowing collections from museums, the Biomimicry Institute mentioned in an interview. Safety testing is unlikely to be eschewed as part of biomimicry product development, so any unsafe products resulting from designing like nature are likely to be discovered as well as they would be in conventional product development protocols. Breakthroughs in science/engineering and technology are likely to further the environmental credentials of future products coming to market, especially when green alternatives to plastics and petrochemicals become commercially viable. In other words, environmental advance in one area is likely to release a cascade of advances in others.

Still, the Biomimicry Institute is fully aware that such an ethical component is not inherently a part of “bio-inspiration” more broadly. Taking steps to define biomimicry as an environmental project is probably the most important focus for advocates helping to shape growth in the field in the coming years. The private and public sectors each have roles to play in this, as the actions in each shape biomimicry and its manifestation in the marketplace. Currently, the private sector is ahead of the public in such steering activities.

**Private sector is steering through education and understanding.** The main biomimicry organizations understand that biomimicry’s spread depends on increase in the population of trained professionals willing to apply biomimicry in business and research. They have endeavored to promote the environmental dimensions of biomimicry, and reinforcing the ethical message in education, training, and marketing will continue to be an important part of making sure practitioners are on the “right” page, assuming a healthier environment is a goal shared by all.

While approaches to messaging may vary by organization, Biomimicry 3.8 provides an example of how it can be done. Perhaps the most important thing, given biomimicry’s current stage of development, is to continue reinforcing and clarifying its ethical message, especially in its education, training, and marketing endeavors. Ethics appear to be a strong component of Biomimicry 3.8’s professional training and certification. On its website, it describes its ethos as “respect for, responsibility to, and gratitude for our fellow species and our home.” The ethos is built into Biomimicry Thinking, or a methodology employed in biomimicry practice. Much of the writing on biomimicry, including that reported in the press, emphasizes its connection to sustainability and is open about its ecological aspirations.

The Biomimicry Institute reported in an interview that certain corporations have been responsive to this presentation and have made biomimicry a part of their approaches to sustainable innovation. Continued framing of biomimicry as compelled by the challenges facing the planet can help cement that purpose in the minds of students, practitioners, policymakers, and the general public. Students, advocates, and consultants learning about biomimicry today are the entrepreneurs and

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37 In an interview, the Biomimicry Institute mentioned that the ethos missing from some bioinspiration practitioners is the commitment to re-connecting with nature and creating the desire to want to preserve nature in order to maintain it as a source of inspiration. “The more animals we lose, the more ecosystems we degrade, the more sources of wisdom that are lost to us,” said the Biomimicry Institute in explaining the importance of a conservationist ethics in its work.
trainers applying it tomorrow. The more it is discussed and taught as an environmental solution, the more it will be understood in that way and approached in that way by private-sector professionals or entrepreneurs. Over time, this can help push an incremental growth of biomimicry.

**The government could do more to push-pull.** Incremental changes can add up to big change eventually, but public sector action is likely to be the big boon for “changing the game” through biomimicry, should the national and state governments take up the mantle. The federal government has been instrumental in numerous cases of transformative innovation in the United States, through combinations of push-pull policies like R&D funding; providing “patient capital,” tax credits and subsidies; creating new markets through government spending; infrastructure development; and public policy. As the imperative for action on climate and the environment grows, biomimicry may become an increasingly attractive focus for federal or state governments looking for transformational technologies. The Biomimicry Institute said robust carbon limits and other sustainability standards will push many corporations to embrace new approaches like biomimicry.

There are many other things that the U.S. and even state governments can do to incentivize “changing the game” through biomimicry, including but not limited to:

- Investing in “patient capital” or other subsidies in strategic sectors for the environment, like energy/utilities, agriculture, automobiles/transportation, building and land use, and chemicals.
- Identify the breakthrough technologies that could accelerate higher-aspiration biomimicry, for the purposes of government and corporate planning.
- Create combined biomimicry/green chemistry components to the federal land grant system and network of extension programs to target agriculture but also the other strategic sectors.
- Establish government purchasing guidelines for agencies and contractors giving preference to products with known energy savings or toxicity reductions of 50% or more.

Being clear that there is a difference between biomimicry focused on environmental problem-solving and biomimicry without that focus is important in policy-making. In light of the critics’ concerns, governments should be discerning in programs to incentivize biomimicry and prioritize projects and startup ventures with environmental dimensions, if progress on planetary health is a motivation. Governmental funding and incentivizing should also spill beyond energy (where much of the federal government focus for environmental policy currently lies). To this end, policy designs can include environmentally-based preference points, with projects scoring higher when planned for positive environmental outcomes in strategic sectors or to commercialize breakthrough innovations. Increased government activities to boost and prioritize ecologically-sensitive biomimicry can only reinforce the

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40 For an overview of the land grant system, see Association of Public and Land Grant Universities 2012. *The Land Grant Tradition.* [http://www.aplu.org/library/the-land-grant-tradition/file](http://www.aplu.org/library/the-land-grant-tradition/file)
way businesses, researchers, and practitioners perceive it and, ultimately may help prevent dilution of biomimicry’s environmental ethos as it gets adopted for profit-making.

Conclusions and Possibilities

Biomimicry is a way of looking to nature for guidance on technological and economic development. The Imagined Economy Project agrees with biomimicry’s advocates: Emulating nature’s adaptations holds promise for re-positioning human enterprise and innovation within the natural world and making the workings of business much more sensitive to ecology. For too long, the global economy has operated in ways tolerant of energy inefficiency, waste, and toxicities. The days of this tolerance may be coming to an end as understanding of the human impact on the environment continues to mount and a growing number of corporations come to accept corporate environmental responsibility.

Biomimicry offers an action plan for industry, scientists, and governments to begin acting toward real, sweeping solutions right now. Progress is already evident in products and processes as varied as packaging, architecture, heating and cooling, road surfaces, cement, transportation, cleaning, irrigation, medicine, agriculture, the list goes on and on. Expanding and strengthening the biomimicry support infrastructure, especially through funding and financing, could help get us to an economy that has closed the loop, contributes to the integrity of the natural system, acts within local opportunities and constraints, and gets to an ecologically-motivated creative destruction— all without needing a new consumer consciousness or a different kind of economy to form first.

Biomimicry may not be the one and only approach to greening the economy, and it will have kinks to continue to work through as it develops and matures. The main challenge for biomimicry in these early moments is clarification of its environmental ethic and self-understanding. Certain friendly critics have shown that biomimicry or the related framework of bioinspiration are not automatically environmentalist at core; instead, sometimes the motive is technological innovation regardless of positive planetary impacts. While there is certainly value in product improvement in its own right, the compelling thing about biomimicry— in the view of the Imagined Economy Project— is its environmental aspirations. In this age of climate change and a probable mass extinction, it is simply time to forge a different path. Biomimicry brings that different path within sight, if only to begin taking the first steps down it.

The history of innovation shows good ideas don’t just happen. Policies and programs make them happen and, most often, through collaboration between governments, industry, nonprofit organizations, and universities. The second report in the Imagined Economy Project’s Biomimicry series examines efforts to promote and get biomimicry to take root nationally and in places, with emphasis on biomimicry promotion in Northeast Ohio. Biomimicry will build exponentially, with technological breakthroughs in one area permitting technological breakthroughs in another. Making biomimicry accessible to existing corporations, emerging entrepreneurs, their support organizations, and young people can accelerate this process, especially if commercial viability and other benefits for corporations, governments, and investors are demonstrated. While the news on the environment is often dire,
biomimicry offers hope and guidance, especially for producers who will be instrumental in transforming human interactions with nature.
### Biomimicry Advocacy Organizations, Research Centers, and Degree Programs

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