Biomimicry in New York State

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ABSTRACT

Terrapin Bright Green and the Biomimicry Guild are working to spur biomimetic innovation in New York State. Through a NYSERDA-funded program, we are engaging manufacturers throughout the state and introducing them to the concept of mimicking natural forms, processes, and systems to create innovative new products and techniques in an industrial setting. Biomimicry is both a methodology and a design mindset that helps identify and solve problems in areas such as energy performance, efficient use of water, toxin reduction, and waste elimination. It helps point the way to advancements that are essential to ensuring the long-term competitive success of NYS companies and to creating more jobs in the state. In this paper, we show the resources that nature holds for industrial innovations, particularly in energy efficiency; we demonstrate with past results that companies can use biomimicry in a number of ways to be successful; and we describe the process that our team has developed to spur biomimetic innovation in New York State.

Looking to Biology for Innovation: Form, Process, Ecosystem

Biomimetic designs use the natural world for inspiration in a variety of ways. First, and most intuitively, biomimicry uses natural forms to inspire the form of manufactured products. Second, biomimicry uses natural processes as models for processes in manufacturing. Finally, biomimicry uses ecosystem-level interactions as inspiration for the organization of human and industrial systems. Companies have used each of these levels of biomimicry to transform their traditional research and development methods. Rather than working incrementally on improving existing ideas, biomimicry can provide entirely new ideas that can be integrated into companies' products and operations in novel ways.

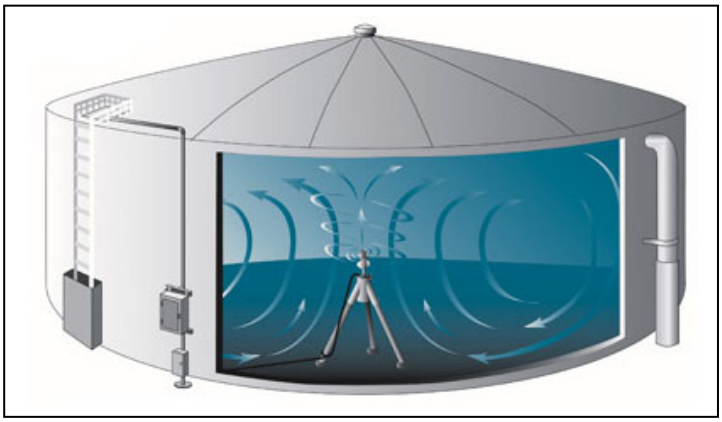
Form

In a successful example of finding inspiration in natural form, a company called Pax Scientific mimicked a form commonly found in nature to achieve impressive energy efficiency gains in rotational equipment. Traditional fans, pumps, and propellers consist of planar surfaces, or surfaces with simple curvature in only one axis. They use these geometries to generate centrifugal forces—forces moving outward from the center of rotation. These forces then generate turbulence that causes the gas or fluid to move or mix. Design faults include drag resistance, low output, energy inefficiency, excessive noise, and component wear and tear. (Oppenheimer and Fiske 2011).

Jay Harman, the founder of Pax, noticed a recurrent geometry in nature that has fascinated man throughout the ages. From water flows, to kelp patterns, to shell architectures, nature repeatedly utilizes 3-dimensional centripetal spirals—oriented toward the center of curvature—for liquid flows. Harman reverse engineeried this geometry in a process that began

with testing shell interiors as impellers and later moved on to more advanced methods using fluid dynamics and computer modeling software. In his first application of this principle to a domestic exhaust fan, Harman created a fan half as noisy, 75% more efficient, with markedly decreased vibration. Further tests demonstrated that the approach could be applied to fluids of all types. One of the most successful applications of the technology is in drinking water utilities, where Pax's Lily Impeller, shown in Figure 1, is able to effectively prevent the formation of biofilm through efficient, low-energy, continuous mixing in water tanks. Prior to Pax technology, mechanical systems for mixing drinking water and preventing biofilm formation used too much energy to be cost-effective for the utilities. Pax allows utilities to maintain high drinking water standards with fewer chemicals and efficient use of energy, thanks to the whirlpool form that the company's founder saw in nature. (Pax Water 2011)

Figure 1. Pax Lily Impeller

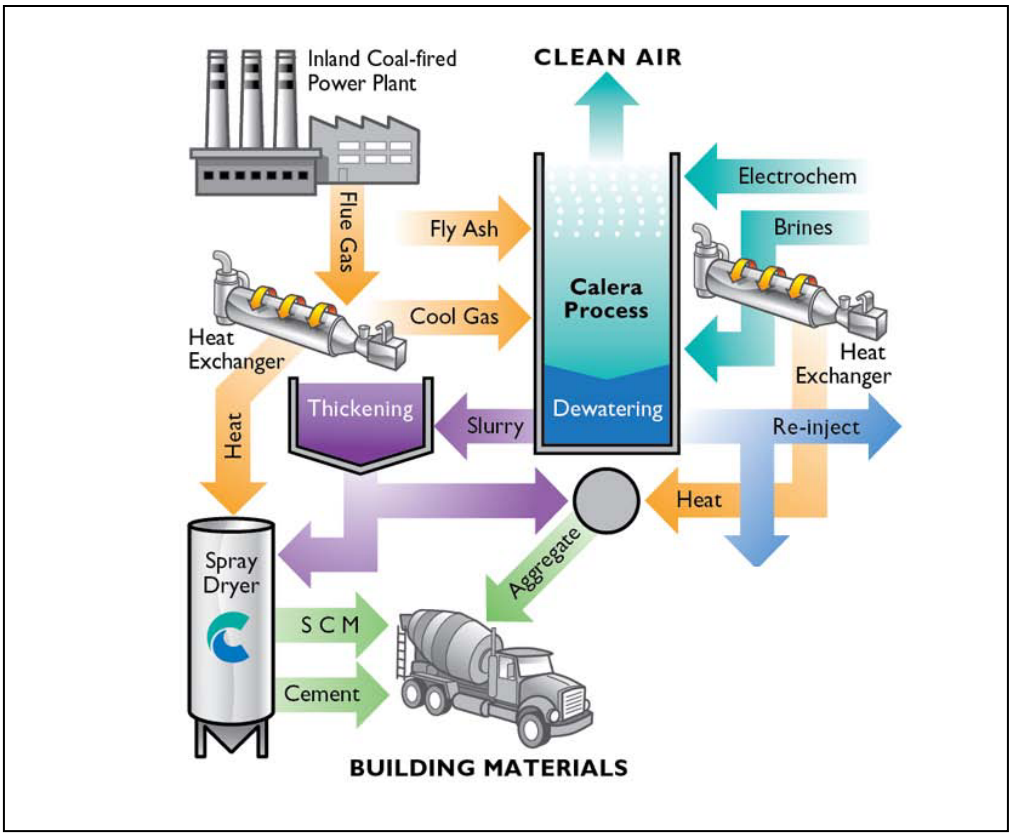


The PAX Water Mixer's Lily Impeller is designed using computational fluid dynamics to reverse engineer the creation of whirlpool flows found in nature. The diagram illustrates the movement the impeller creates. Source: Pax Water 2011.

Process

Inspiration from natural processes has made many contributions to industry. One potentially transformative new example is the inspiration that a company called Calera derived from the process by which coral reefs are formed from carbon dioxide and minerals in ocean water. Modeling the ocean chemistry that allows this to take place, Calera developed a process called Mineralization via Aqueous Precipitation (MAP), illustrated in Figure 2, that involves bubbling carbon dioxide-laden gases through water, then precipitating the carbon dioxide to form bicarbonate, calcium carbonate, and magnesium carbonate. Calera produces cements, supplementary cementitious materials, and synthetic limestone using MAP, which can replace mined building materials (Calera 2011). Calera's products include paving stones, concrete, and other building materials, and represent a form of sequestered carbon dioxide. Calera's potential to replace cement is particularly important, as the production of Portland Cement represents the third largest anthropogenic source of carbon dioxide production. Calera is currently working to scale its operations to be able to sequester carbon dioxide from the flue gases of coal-fired power plants, and expects to be able to trap more than 70% of gases released from power plant stacks. This process would make Calera products carbon-negative building materials.

Figure 2. Calera Process



Calera's Mineralization via Aqueous Precipitation process mimics the process of coral reef formation in ocean water. Source: Calera 2011.

Ecosystem

Ecosystem-level interactions in nature can provide useful models for how to organize industrial and human systems on a broader scale. The concept of Industrial Ecology is inspired by the ecological principle that one organism's waste product provides another's feedstock, such as fungi that make use of decomposing plant matter for their growth. Kalundborg, Denmark, is the most well-known example of a successful industrial ecology system. The industrial town of Kalundborg is anchored by 5 main entities that exchange flows of materials and energy to produce efficiencies: Asnaes Power Station, a 1500-MW coal-fired power plant; an oil refinery operated by Statoil; Novo Nordisk, a pharmaceutical company; Gyproc, a plasterboard manufacturer; and finally, the municipality of Kalundborg (Ehrenfeld and Gertler 1997). Asnaes provides its waste heat to the municipality of Kalundborg in the form of a steam heat system; homeowners pay for piping in exchange for receiving reliable and inexpensive heat. In its first 15 years, this system and the formerly unused waste heat that powers it eliminated the use of 3,500 oil-fired residential furnaces. Asnaes also provides steam to Novo Nordisk and a gypsum-containing feedstock, made from the calcium sulfate produced by the power plant's sulfur dioxide scrubber, to Gyproc. Statoil, which had previously flared waste gases, began in 1972 to provide Gyproc with those gases, which fulfill all of Gyproc's power needs. Statoil also provides cooling water to Asnaes, where it becomes boiler-feed water, reducing water demand by 25%. Novo Nordisk produces a nutrient-rich sludge as a by-product of its pharmaceutical operations,

which it distributes to farms in and around Kalundborg as a valuable fertilizer. These and other interactions create a complex web of material and energy exchanges within Kalundborg, but each interaction has been created as an independent business relationship between parties. The industrial ecosystem at Kalundborg now serves as a model for other industrial parks attempting to improve their environmental performance.

The Biomimetic Process: Results from Successful Biomimetic Innovations

Our program aims to move companies closer to biomimetic innovation. In order to do this, we set out to understand the various ways in which companies have achieved financial success as well as environmental improvements using biomimicry. We have found that companies use biomimicry in a number of very different ways, each presenting unique opportunities depending on the business' capabilities, budget, and size. The first ways that companies can use biomimicry for financial success is to pursue a biomimetic solution to an existing challenge within the company. Second, a company can seek out existing biomimetic research that addresses a challenge the company has, and find ways to integrate that research into the company's response. Third, entrepreneurs can found a company wholly on a new biomimetic idea, tailoring their marketing and operations to the opportunities provided by the biomimetic technology. Here, we show results from companies that have used these three different techniques to grow their businesses and improve their environmental performance through biomimicry.

Using Biomimicry Workshops to Develop New Innovations: InterfaceFLOR

The experience of InterfaceFLOR, the world's leading manufacturer of modular carpet tiles, shows how an existing company can begin to look to biomimicry to solve existing challenges within a company. Interface has had enormous success using biomimicry, and has integrated the biomimetic design process into its standard research and development process.

In 1996, Interface participated in a workshop led by the Biomimicry Guild with the broad goal of looking to natural systems for potential improvements to Interface's carpet designs (Anderson 2009). InterfaceFLOR's design team was asked to take a walk through the forest in search of ideas. It was not the shapes of flowers or leaves that stood out as the team examined the natural world around them, but the pattern of leaves on the forest floor. In nature, the team realized, a surface that appears homogeneous is actually made of many unique parts, arranged in a pattern of "organized chaos." Just as no two leaves on a forest floor have to be same for the forest floor to appear homogeneous, the team imagined that no two modular tiles had to be the same for a carpeted floor to appear homogeneous. This workshop led to a new carpet design concept based on the arrangement of leaves on the forest floor (James 2011).

Following this revelation, InterfaceFLOR launched i2, a line of modular carpet that uses non-uniform design schemes. Traditional carpet tiles must all match exactly, and must be installed uniformly in the same direction. i2 carpet tiles, on the other hand, are manufactured with a variety of patterns. Patterns that have a similar look are mixed and matched within each carpet installation, and are arranged in random order, creating the visually pleasing "organized chaos" that the design & development team observed on the forest floor. Because the tiles do not need to be identical, carpets in the i2 line can be composed of dye batches that are similar, but not necessarily identical. This eliminates an enormous amount of waste generated during the

manufacturing process, since the requirement that all tiles be identical had previously resulted in the rejection of batches that looked slightly different. Because the i2 line's modular tiles do not require perfect fit or matching colors when fully assembled, the line also reduces waste generated during installation, going from approximately 4% wastage for standard carpet tiles to approximately 1.5% for i2 tiles. With this innovation, InterfaceFLOR greatly improved its manufacturing efficiency (Meezan 2011).

The environmental benefits of i2 products are clearly enormous. The avoided waste due to the introduction of i2 products has contributed to Interface's ability to reduce the total waste sent to landfills from manufacturing facilities by 77% since 1996. Financially, these material waste reductions make an enormous difference in the bottom line. For example, in one recent 29,200 sq. ft carpeted installation, InterfaceFLOR saved $24,420 in production costs by manufacturing i2 products rather than conventional modular carpet tiles. This allows them to be more competitive in the marketplace and increase their profit margins. The i2 line's ingenious design and resulting savings for both the company and the consumer have made it a runaway success in the modular carpet industry (Meezan 2011). According to Ray Anderson, founder of Interface Inc., Entropy, the first offering in the i2 line, became the most popular product in the company's history, faster than any other product in the company's history (Anderson 2009). Sales of i2 products have increased steadily since their release. From 2005 to 2008, InterfaceFLOR's i2 sales increased by 3.1 million yards, and by 2009, the company's accumulated avoided costs from its waste elimination activities, including the substitution of standard carpet tiles with the i2 line, equaled $433 million (Bradford 2011).

After its success with the i2 line, the company became a strong proponent of biomimicry, and began seriously investigating other applications to their products and processes (Oakey 2010). One problem that had plagued InterfaceFLOR's design and development team was how to eliminate glues that off-gas volatile organic compounds (VOCs) and impede the recycling of carpet tiles. InterfaceFLOR's design and development team had been wrestling for some time with the elimination of glues from their carpet tiles. Conventional modular carpets were glued to floors using liquid glues that issue volatile organic compounds as they cure. VOC's can contribute to poor indoor air quality (Colando 2011).

Designing a carpet installation without glue was challenging. The research and design team involved in InterfaceFLOR's brainstorming meeting began to question how nature "does glue." The team initially focused on a compelling example of "glue" in nature- the way gecko feet manage to stick to surfaces with enormous strength and without leaving any type of residue. The team hoped to mimic the powerful adhesive forces in gecko feet with a new carpet glue. Such a project, however, would have been an enormous undertaking involving years of research and development. Developing the technology to mimic gecko feet was simply not feasible; the design team began to think that they needed to pursue another avenue of thought. With the help of the Biomimicry Guild, the team at InterfaceFLOR realized that they had been asking the wrong question all along. The team should have been asking not how nature makes glue, but how nature keeps a surface covered. Nature uses the simplest method available -- rather than using a complex glue, gravity holds things in place on a surface. If each modular tile in a carpet is held together, gravity can do the work of keeping the tiles on the floor, and there should be no need for conventional glued carpets (Colando 2011).

Chief Innovations Officer John Bradford and his design team realized that they needed to find a way to stick the carpet tiles together rather than finding a way to stick to the carpet tiles to the floor. Drawing inspiration from a flexible stamp of PVC plastic, the team invented the

TacTile, a slim, post-it sized stamp that uses a thin layer of resealable glue on one side to adhere tiles to each other, creating conglomerates of tiles that act as wall-to-wall carpeting or area rugs. Since the tile construction itself prevents them from curving and bending at the corners, and gravity holds the carpet down, TacTiles eliminate the need to glue each tile to the floor, also eliminating damage to the floor and exposure to volatile organic compounds. In fact, the elimination of liquid glue in carpet installation virtually eliminated emissions of volatile organic compounds that normally off-gas from these components (Bradford 2011).

Since TacTiles use a non-liquid glue to hold tiles to each other rather than gluing them to the floor, the device eliminates damage to flooring when the time comes to remove the carpet. From an environmental perspective, TacTiles provide a wonderful alternative to the volatile organic compounds (VOCs) that off-gas from conventional liquid glues. The environmental impact of using TacTiles is 90% lower than that of traditional glue adhesives, as they perform the same function with dramatically less material, and furthermore require much less packaging: TacTiles are packaged in small cardboard containers, rather than the large plastic buckets used for liquid glue (Colando 2011). TacTiles contributed to more effective recycling at Interface in two ways. The company's Re-Entry program, in which the company reclaims old, worn products and recycles them into new products, now accepts TacTiles for recycling, adding another recyclable component to the carpet installation. Even more significantly, the use of TacTiles has eliminated the largest obstacle to recycling carpet tiles, residual glue on the product (Colando 2011).

The innovation behind TacTiles has made it a huge success, since carpet installation is now easy enough for clients to tackle at home and the environmental benefits appeal to concerned consumers. One of the most appealing benefits of TacTiles is that clients can install tiles by themselves, without the aid of an installation crew. Sales of TacTiles have skyrocketed since their launch in 2006. In 2006, InterfaceFLOR sold 1.5 million TacTiles, but that number rose to 8.9 million in 2007, and then to 14.8 million in 2008. As of the third quarter of 2009, 25% of all InterfaceFLOR's orders used TacTiles (James 2011).

Finding Biomimetic Research that Solves a Company Challenge: PureBond

Unlike Interface, Columbia Forest Products found existing biomimetic research that addressed a company challenge and supported the development of a technology based on that research. The company saw enormous success from using biomimicry, but rather than beginning with an entirely new biomimetic design process, the company tapped into the rich bank of existing research that looks to natural systems for innovation.

Columbia Forest Products has long been dedicated to environmental responsibility. The company was the first decorative hardwood plywood manufacturer to have their products certified to Forest Stewardship Council standards in 1998 by SmartWood, a division of the Rainforest Alliance (Columbia Forest Products 2006). After investing a significant amount of money in ensuring that their wood was sustainably harvested, Columbia Forest Products realized that they required wood products that were toxin-free to meet both market demand and their own commitment to sustainability. Conventional wood glues contain levels of formaldehyde that are labeled carginogenic by the World Health Organization due to their off-gassing volatile organic compounds (VOCs) (Pung 2011).

For four years, Steve Pung searched for a non-toxic alternative to Columbia's conventional wood glue. Unfortunately, the market simply did not offer a cost-effective

alternative, as the available glues were made of expensive synthetic materials that could not be affordably integrated into Columbia's products. However, when Pung met Dr. Kaichang Li, an assistant professor at Oregon State University's Department of Forest Products, he saw the potential for an entirely new way to approach wood glue (Beckman 2011). Dr. Li explained that he had been wading in waters off the coast of Oregon when he noticed a group of mussels clinging tenaciously to a rock beneath the surface of the water, despite the thrashing waves all around them and the slippery, uneven surface of the rock. Li wondered how these creatures produced an adhesive that was effective enough to withstand the dirt on the rocks, the pressure of the waves and the unpredictability of the surface area. Compared with human-made glue, this adhesive, whatever it was, was remarkable. Li went home determined to figure out the secret behind the glue. After several months of tests in his laboratory at Oregon State University, Li discovered that mussels secrete a thread-like protein called byssal threads that adhere to wet and uneven surfaces. These byssal threads are strong enough and flexible enough to absorb the energy caused by constant movement of the waves (Li 2011). Li now set out to find a similar protein that would work in glue.

Li discovered a way to make soy protein comparable to byssal threads, changing its composition to match that of byssal threads themselves. With funding support from Columbia Forest Products, Li devised a process of crosslinking soy protein with a unique recipe of curing agents and propriety materials to make it water resistant. The process of thermal setting and cross-linking the soy glue was patented by Columbia Forest Products as PureBond Technology (Piland 2005).

At the end of 2003, Columbia Forest Products began to incrementally integrate PureBond Technology into its manufacturing plants. By the end of 2005, the company's processes had been refined, and by the end of 2006, so had all the machinery. By the beginning of 2007, Columbia had successfully incorporated PureBond technology into all of its manufacturing plants and had ceased to produce any products containing added urea-formaldehyde (Pung 2011). The company found almost immediately that customers responded to the availability of a product free of added VOC's. In fact, where consumers previously had no reason to recognize the brand of the plywood or veneer used in their cabinetry or other products, Columbia Forest Products created a recognizable brand name that customers began to ask for specifically (Pung 2011). Columbia credits its survival of the recent recession to PureBond Technology: according to the Hardwood Plywood and Veneer Association, North American plywood and veneer production fell by about 35% from 2008 to 2009. The only segment of the market that remained relatively stable was the group of suppliers and purchasers of environmentally responsible hardwood plywood products. By adopting non-toxic adhesive technology early on, Columbia captured a large portion of this market and maintained consistent production throughout the recession (Howlett 2011). Moreover, whereas competitors began to offer a no-added-urea-formaldehyde option to customers at a price premium over their standard product, Columbia had re-configured all of its machinery so its products without added urea formaldehyde were not a premium offering within the company (Pung 2011).

Despite the fact that it supplies products far upstream from the end user, Columbia Forest Products is lauded in parenting and environmental publications. Considering that end-users of furniture never encounter manufacturers of materials so far up the supply chain, Columbia enjoys an unusual amount of fame resulting from their PureBond Technology. In fact, Columbia Forest Products receives so much publicity and so many requests for products made with PureBond that

the company's marketing department set up searchable databases that will allow interested customers to find a fabricator of furniture made with PureBond products (Vogelsinger 2011).

Forming a New Company Based on a Biomimetic Innovation: ReGen Energy

In a third example of how companies have succeeded with biomimicry, REGEN Energy is a company that was founded around the development of a new biomimetic idea.

Fascinated by building systems and energy efficiency, the company's founders realized that reducing peak loads benefits both the stability of the electricity grid and energy consumers (Kerbel 2011). A substantial amount of the grid's generating capacity is reserved for satisfying demand during peak periods that may occur as rarely as a few dozen hours per year. That power is extremely costly, since it requires entire ancillary power plants. The two focused on the idea of "emergence" in nature, after reading Steven Johnson's *Emergence: The Connected Lives of Ants, Brains, Cities, and Software*. Many social organisms seem to make sophisticated adjustments and decisions based on relatively simple rules. This is how bees are able to operate an adaptive colonial group, despite lacking top-down management or "intelligence" in the human sense of the word. Using simple rules and communicating constantly with pheromone trails, each individual bee contributes to the hive-level goal of survival. The phenomenon is called "emergence" because a complex system of communication and decision-making emerges from a large number of much simpler interactions. Kerbel and Kulyk developed an algorithm based on the communication between bees that allows all pieces of building equipment to simultaneously detect each other, to red-flag unnecessary power consumption. Air conditioners, compressors, pumps and other building appliances constantly cycle on and off. The problem arises when they are ignorant of each other and turn on at the same time (Hamilton 2009).

To solve this problem, REGEN developed the EnviroGrid Controller to connect to the control box on each piece of equipment, to function as a smart power switch. Each device monitors its appliance's energy use every two minutes and broadcasts its reading to all the other controllers in the system. Once several controllers have been activated, they learn the power cycles of each appliance and use a networking standard called Zigbee to communally negotiate the best times to turn equipment on and off. Every node connected to the REGEN "hive" thinks for itself. Before making a decision, a node considers the circumstances of other nodes in the network. For example, if an HVAC unit needs to cycle on to maintain a minimum temperature, a node connected to another HVAC unit will stay off for an extra 15 minutes to maintain power use below a certain threshold (Kerbel 2011).

Since its establishment, REGEN Energy has been lauded by local and national media coverage for its innovation, and has been commended at clean-tech conferences. REGEN was ranked in the top 10 Smart Grid Companies to Watch Out For by SmartGrid News. The company was also an award-winner in the Clean Tech category of Canada's Top 10 Competition (Kerbel 2011).

REGEN's technology has proved to be effective in reducing both peak demand and overall energy consumption for its clients. In 2010, for example, REGEN installed EnviroGrid Controllers in a chain of movie theaters in New Mexico with impressive results. The installs ranged across several different areas of New Mexico, also ranging across three different utility companies. The return on the initial investment (ROI) for this particular installation was an impressive 1.23 years, considering most competing technologies yield an ROI of around 3 years. Most REGEN installations yield an ROI of under 3 years, and often end up with less when

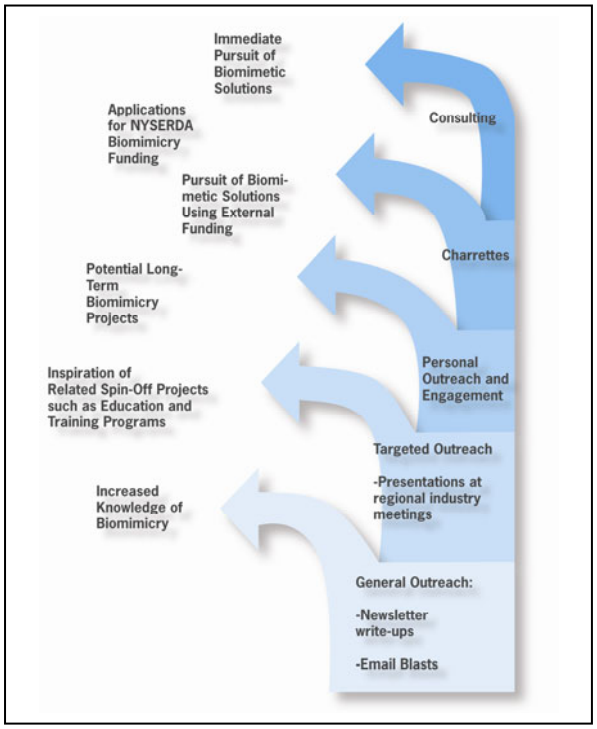
combined with the utility-sponsored financial incentives that many of these installations receive. Most of REGEN's clients see an overall energy demand reduction of nearly 20% (Kerbel 2011).

NYSERDA Program Process

Given the potential benefits that biomimicry can bring to companies, NYSERDA has become interested in helping New York State companies innovate and reduce their energy costs by using biomimicry as a design process. Terrapin, the Biomimicry Guild, and our team of outreach partners have crafted a process designed to bring New York State companies closer to creating new biomimetic innovations and incorporating existing biomimetic products and processes into their operations. The innovation program includes multiple levels of involvement with companies, all the way from general presentations through individual focused consulting. Through participation in each level of involvement, a company will gain increasing levels of benefit from our program.

Taking our cue from the variety of ways in which companies can use biomimicry, our program seeks to promote the adoption of biomimicry through multiple pathways. By conducting workshops and individual consulting with companies, we help existing companies solve their energy-related challenges by looking to biomimicry. By creating a network of researchers, companies, and others interested in biomimicry, we help match companies with existing biomimetic research that may help solve the company's energy and innovation challenges. By building New York State's biomimicry community, we increase the potential for entrepreneurs to create successful companies based on new biomimetic ideas.

Figure 3. NYSERDA Program Process



Multiple levels of involvement provide a variety of outcomes for companies, and a number of opportunities for biomimicry to infiltrate New York State industries.

Outreach

Our process begins with outreach to individual companies, industry associations, and other groups throughout the State. Biomimicry is a new concept for many companies, and we work to show the potential benefits to companies that wish to develop their products and processes. Our team includes:

- The Manufacturers' Association of Central New York and the Manufacturers' Alliance of New York, two large industry associations with whom we have worked to plan outreach events and to target individual companies;
- The Long Island Forum for Technology, a Long Island consortium of manufacturers with extensive knowledge of the island's companies and their potential for innovation;
- The Syracuse Center of Excellence, a division of Syracuse University with a focus on industry collaboration;
- The New York Industrial Retention Network, an organization that works closely with manufacturers within New York City;
- NYSTAR, which is helping to coordinate contacts with industry representatives throughout the State;
- Erika Hanson Design, a small company that works frequently with industrial clients to identify sustainable solutions to design problems.

At the beginning of our outreach efforts, we created a toolkit for our partners to use, including write-ups on biomimicry, powerpoint slides on various aspects of biomimicry, and detailed case studies on businesses that have had success with biomimicry. We have worked with each of them to interest their constituent companies in the use of biomimicry.

Selecting Companies

After casting a wide net for possibly interested companies, we proceed to select companies for participation in more in-depth charrettes, where we explore specific energy-related challenges that the companies share. Qualifications we look for in companies selected for further participation are:

- An organizational commitment to pursuing biomimicry as an innovation tool;
- Team confidence and diligence in pursuing new ideas;
- Ability to prototype and test new designs, products, or processes;
- Ability to communicate biomimicry.
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In addition to characteristics of the individual company, we look to find a group of companies working to solve related challenges. This way, the shared brainstorming that takes place during the charrette is potentially useful to multiple attendees.

Charrette Process

We research biological strategies relevant to each cross-industry challenge that will be part of the discussion at a charrette. We match these energy issues with experienced biomimics

who can brainstorm with manufacturers to generate inspired solutions in a charrette format that includes presentations and collaborative working groups. Charrettes are also an opportunity to reshape stakeholder expectations with regard to traditional barriers to collaboration between industry and researchers. These barriers can include differing budget constraints, development processes and schedules, deployment timelines, and expectations of returns on investment. The charrettes are structured to foster matchmaking between participants that may lead to proposals for focused consulting and, eventually, feasibility studies.

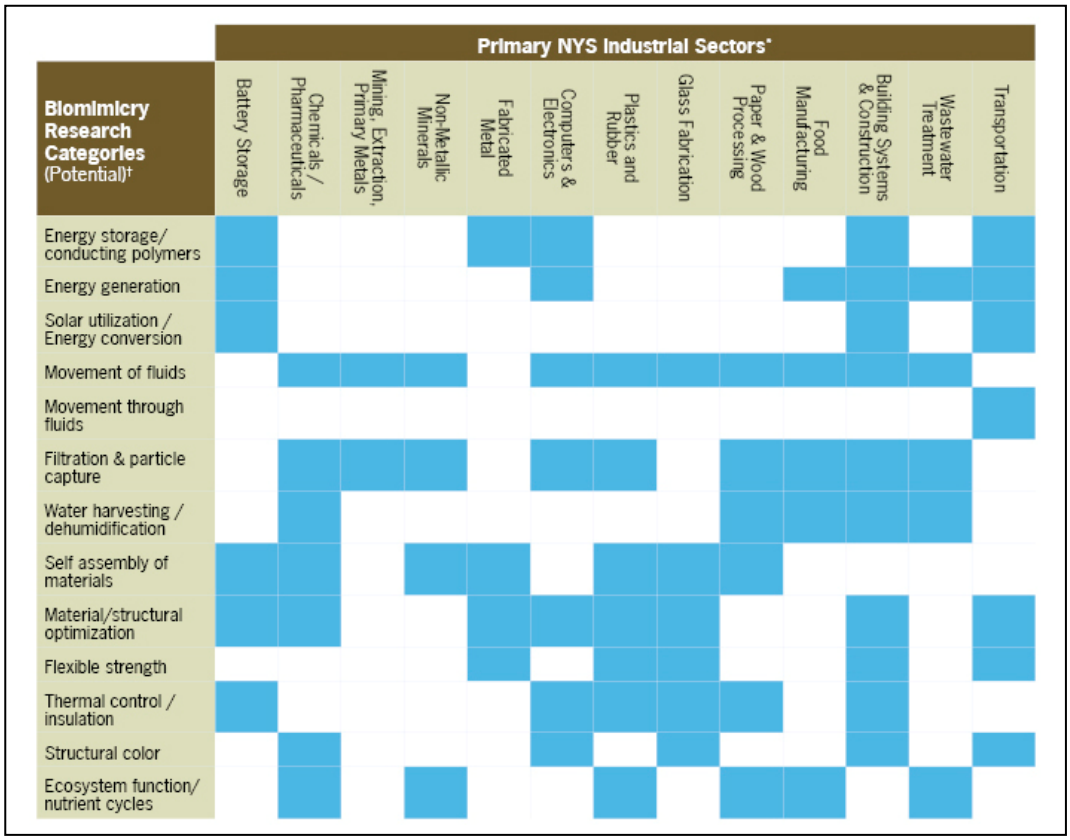
Consulting

Building on the ideas and excitement created in the Industry-Related Biomimicry Charrette, our team can meet privately with a select number of interested companies from the charrettes to strategize on how to move forward with their biomimetic inspiration. In these sessions, we work with senior leadership and internal experts to provide insight into the process they should follow, address concerns about the biomimetic process, and provide them with additional resources. This may include a proposal for additional services from a team of biomimetic experts to support the company's internal efforts. NYSERDA is interested in funding additional research that may lead a company to a successful biomimetic innovation, and we can work with companies to develop proposals for further NYSERDA funding.

Conclusion

We believe that New York State's industries will benefit tremendously from increased awareness and use of biomimicry as a tool for innovation and energy efficiency. Building systems, chemistry companies, and battery and energy storage technologies are just some of the New York State industries that could benefit from biomimicry. Figure 4 shows potential intersections of areas of biomimetic research and the needs of New York State industries. Our program is designed to identify these intersections and promote the adoption of efficient, economically advantageous biomimetic technologies.

Figure 4. Intersections between Biomimicry Research and New York State Industries



Sources: US Energy Information 2009; NYS Pollution Prevention Institute 2009; Biomimicry Institute 2009, and Benyus 1997.

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