

Learning from Nature: the Beauty & Value of Biomimicry

Sustainable innovation inspired by nature is not new, but it's never been more relevant

By Robert Grace

We humans think we're so damn smart. But some of the planet's other 30 million or so species are pretty clever, too—and most have been playing the game a lot longer than we have. If we just ask the right questions, we can learn a lot from nature to solve difficult design and engineering problems.

That was the message delivered last month by Seth GaleWyrick, senior mechanical engineer and sustainable design specialist at Bresslergroup, at SPE's second Design in Plastics conference, held Nov. 6 to 8 at the College for Creative Studies in Detroit.

GaleWyrick, who lives in Montana, has worked for 12 years at the 65-person, Philadelphia-based design firm, and has spent the past three years studying biomimicry—which is simply a tool set for innovation based on learning from biology. He is currently two years into pursuing both his Master's degree and professional certification in biomimicry. He is one of 18 students in the first-of-its-kind program being offered online by Arizona State University.

The track record for new product development is underwhelming: 25 to 45 percent of new goods fail, according to the Product Design & Marketing Association, and 95 percent



Jamison Float of Priority Designs (above) submits to an ultrasound test to help gauge the jugular compression effects of the Q-Collar that his team helped develop. Such tests were used to verify jugular restriction, and MRIs confirmed brain blood volume and elasticity. These tests established that early prototypes accurately replicated the jugular compression of the omohyoid muscle found in woodpeckers. Courtesy of Priority Designs



GaleWyrick: "What if relying only on human cleverness is holding us back?"

of all new products miss their targets, according to the U.S. Department of Commerce. And that doesn't even account for all the goods that never make it to market.

So, GaleWyrick asked the audience, "What if relying on *only* human cleverness is holding us back?" The first organism appeared on this planet some 3.8 billion years ago, and life has been evolving solutions to most of our problems ever since.

"That's the promise of biomimicry," notes GaleWyrick. Instead of looking at a problem and asking, 'Have we done this before?', he suggests we ask a biologist if *something else* has done this before. The design solutions found in the natural world are so beautiful, elegant, and functional that designers and engineers should truly be inspired.

Here are just a couple examples:

Swimming with the sharks: Container ship hulls are a magnet for barnacles and bacteria growth and the like. Worldwide, these organisms combined cost companies an estimated \$67 billion a year due to extra drag they create. It's a problem that's been addressed many times in the past few hundred years, usually by coating ships with a wide range of incredibly toxic substances—typically heavy metals—that basically kill everything they touch. But does that seem like a good idea for things floating in the same ocean that generates half the oxygen on earth and that provides much of the seafood that we humans consume?

Ask a marine biologist. It turns out that sharks have been working on this same problem for more than 400 million years. These fish have developed geometrically shaped scales with tiny ridges that create micro vortices that inhibit the growth of biofilms. Bacteria and algae cannot colonize and

spread on such structures, due to the shape, with the result that this "design" also serves to reduce drag. Sharks couldn't afford to poison the ocean where they live, so they evolved a more elegant, efficient solution, one that is in the process of being adopted on airplanes and ship hulls, and even in hospital settings, to help minimize the spread of hospital-acquired infections.

Taking the sting out of your injection: The design of the modern hypodermic needle seems counterintuitive. It features a series of very tiny bevels that, when magnified to the human eye, look like a nasty saw blade with a painful jagged edge. But these bevels make the blade sharper and more comfortable while sliding through the skin. Entomologists studied mosquitos to determine how they manage to pierce your skin while barely being detected. It turns out that, at this scale, the points actually trigger far fewer nerve endings and you barely feel the jab.

These are examples that offer an obvious, direct translation to human needs. But biomimicry is rarely this direct.

Making PHA resin, naturally

Take the work being done by Newlight Technologies Inc. of Costa Mesa, Calif. Microbiologists in the 1980s discovered there are microorganisms that naturally generate a type of plastic called polyhydroxyalkanoate, or PHA, in their cells. This initially generated a lot of excitement, but research failed to find a way to commercialize this bioresin cost-effectively.

Founded in 2003, after 10 years of research, Newlight (www.newlight.com) says it has "developed, patented, and commercialized the world's first commercially scaled carbon-capture technology able to produce high-performance thermoplastics from air and methane emissions that can



Priority and its partners had to determine if the Q-Collar was safe, effective, and if it could be used by humans without any adverse health or performance issues. A variety of rigorous safety and performance tests performed at multiple institutes demonstrated no negative effect on performance, effort, or response time, and no changes to brain function or chemistry.

Courtesy of Priority Designs

match the performance of oil-based plastics and out-compete on price.”

The firm’s resulting PHA material, called AirCarbon, combines air with methane-based carbon emissions—carbon that would otherwise be part of the air we breathe—to produce a material that is approximately 40 percent oxygen from air and 60 percent carbon and hydrogen from captured methane emissions by weight. They claim it costs less than oil-based thermoplastics.

In March 2016, IKEA Group—the Swedish home-furnishings giant—announced it had entered into a 10 billion-pound supply, collaboration, and technology license agreement with Newlight that will provide IKEA with AirCarbon from the California firm’s commercial-scale production facilities and enable IKEA to produce AirCarbon thermoplastic under a technology license.

Under the agreement, IKEA said it will purchase half the material from Newlight’s 23,000-tonne-per-year plant in the United States, and subsequently IKEA has exclusive rights in the home furnishings industry to use Newlight’s carbon-capture technology to convert bio-based greenhouse gases, first from biogas and later from carbon dioxide, into AirCarbon thermoplastics for use in its home furnishing products.

The two firms have a long-term goal to develop capacities up to 1 billion pounds per year. IKEA’s aim is for all the plastic material used in its home furnishing products to be renewable or recycled material.



As in woodpeckers, slightly compressing the jugular vein in humans also causes blood to fill the cavity between the brain and the skull, thereby reducing “brain slosh” and creating a cushion that has been shown to greatly mitigate the effects of mild traumatic brain injuries such as concussions. Courtesy of Priority Designs

Coining the phrase

Biomimicry literature is full of thousands of cases studies and those are just the ones identified since author and innovation consultant Janine Benyus coined the term 20 years ago. New Jersey-born Benyus is the foremost expert on this topic, and wrote the first of her six books in 1997, called *Biomimicry: Innovation Inspired by Nature*.

In a 2009 TEDGlobal Talk, she said: “We live in a competent universe. We’re part of a brilliant planet, and we are surrounded by genius. Biomimicry is a new discipline that tries to learn from those geniuses, and take advice from them, design advice.”

She currently runs Biomimicry 3.8 (<https://biomimicry.net>), her for-profit consulting company, and the Biomimicry Institute (<https://biomimicry.org>), a Missoula, Mont.-based nonprofit she co-founded in 2006 with Bryony Schwan. The latter also hosts an interactive informational website called AskNature.org (www.AskNature.org).

About woodpeckers and concussions

A team at Priority Designs in Columbus, Ohio, meantime, has been following Benyus’ advice. Jamison Float, senior biomedical engineer at Priority, is leading the project to create a device designed to mitigate the effects of concussions through biomimicry.

Float, who also spoke at the recent Design in Plastics conference, said there are 3.8 million sports-related concussions in the United States each year, and that brain injuries are also a major issue for the military.

He explained how Dr. David Smith, an internist with a degree in chemistry, began researching the issue after being challenged by a U.S. military general to figure out

why woodpeckers — which hit their heads 80 million times over a lifetime— don’t get concussions. After a year of study, Smith realized the woodpecker activates the omohyoid muscle in its head upon impact to apply slight pressure on the jugular, which slightly increases blood volume in the brain, creating a sort of cushion.

When the head experiences an



impact of extreme force, “slosh” is the movement of the brain as it is floating in the cerebrospinal fluid inside the skull. As the brain sloshes inside the skull it can rotate or strike the walls of the cranium, often tearing brain fibers resulting in mild traumatic brain injury (mTBI). An extreme force to the brain can result in concussion, but smaller, repeated impacts can lead to chronic traumatic encephalopathy (CTE), which is a form of brain damage resulting in dementia.

Humans also have an omohyoid muscle, but little was understood about what it did. Over the next seven years, neurosurgeons, researchers, engineers, and designers performed extensive research to determine how to replicate the action of the woodpecker’s omohyoid. The team faced challenges that included how to deliver the appropriate pressure, material and fit. Using a variety of existing and emerging medical technologies, they tested prototype device after device to verify safety and efficacy.

Smith then convinced neurosurgeon Dr. Julian Bailes, who is a former Pittsburgh Steelers physician and a character portrayed in the 2015 football movie “Concussion” starring Will Smith, to test his jugular-constriction theory by using the device on rats. The study revealed an astonishing 83 percent reduction of concussion-related protein development in the rats’ brains, whereas previous methods of protection had resulted in a change of no more than 5 percent.

Excited by the results, Smith licensed the technology to a small, Westport, Conn.-based sporting goods and medical device manufacturer named Q30 Innovations LLC (www.q30innovations.com), which already worked with Priority Designs and asked them to join the project.

Extensive further testing and development followed. Designs were careful to reduce or eliminate pressure on the trachea as not to interfere with breathing. The solution was a C-shaped collar with a curved profile to keep the device low on the neck. It applies slight pressure to the neck that mildly increases blood volume in the brain to create a cushion that reduces movement of the brain inside the skull.

The resulting product—dubbed the Q-Collar—addresses the problem from the inside out by mimicking the woodpeckers’ natural defense. Priority describes it as “the world’s first technology to use the body’s natural physiology to protect against mild traumatic brain injury caused by concussive events.”

Extensive (and ongoing) testing has confirmed the safety benefits of the Q-Collar, while also demonstrating it has no negative effects on the wearer’s performance, effort or response time.


Priority Designs has worked closely with Q30 Innovations to transfer the device to manufacturing for commercialization, and is partnering now with Sussex, Wis.-based injection molder Sussex IM. The Q-Collar is currently in production with a Canadian launch for late 2017 as it undergoes review in the U.S. by the Food & Drug Administration.

Editor’s Note: *Arizona State University (Master’s program) and the University of Akron (Ph.D. program) are the only two U.S. schools that currently offer degrees in biomimicry. Additionally, the Minneapolis College of Art & Design, the University of California – Berkley, and the Savannah College of Art & Design also offer biomimicry courses.*

ABOUT THE AUTHOR


Robert Grace is a writer, editor and marketing communications professional who has been active in B2B journalism since 1980. He worked for 25 years at *Plastics News*, as founding editor as well as its associate publisher, conference director and business development director. He was managing editor of *Plastics Engineering* from July 2016 through October 2017, and also is editor of *SPE’s Journal of Blow Molding*. He now has his own firm, RC Grace LLC, in Akron, Ohio.









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How to Apply Biomimicry to Your Product Development

Biomimicry offers tremendous promise for helping those who design and develop products. But how does one practically apply such principles? Bresslergroup's Seth GaleWyrick served up the following advice at the SPE's recent Design in Plastics conference in Detroit.

The good news, he says, is that you don't have to change the way you design things. "You don't have to reinvent the process of design and engineering. What we are doing is adding information to that process." When you are doing your early-stage, new-product benchmarking research, and assessing user needs, etc., that is the time to do your biological research, as well.

"The key to making this work is function. In biomimicry," notes the design firm's senior mechanical engineer and sustainable design specialist, "function is the shared language between our technical sciences and biology." Once you nail down exactly what you want your product to do, that is when you engage biologists.

However, he cautions, "if you go to the biology department at a university and say, 'Help me identify strategies for a car bumper,' they might look at you like you're crazy, because biologists don't study car bumpers. But if you say, 'Help me find strategies in nature for mitigating impact,' they'll be like, oh, yeah, totally."

The challenge then is to look at nuts and beetle exoskeletons and woodpecker skulls, and figure out how they're doing it. So, the *functional translation* is the key step. Then, you let the biologists do their job.

Don't try this at home

"Here's a big caveat," GaleWyrick says. "Don't try to do this stuff by yourself. I can't do this stuff. The idea behind multidisciplinary is not to learn the skill from the other

discipline; let the biologists do the biology. They will find and uncover more incredible things in their time than you ever could. A good team of biomedical biologists is likely to uncover 50 to 100 organisms in a matter of a week or so."

Then, once the biologists come back to you with their findings, you do the next step together.

"This is the reverse translation. You have to get back to doing design. You generate what we call an NTS, a Nature's Technology Summary. This is a one- to two-page document that defines what is being done, how is it being done, and most critically for the reverse translation, how do we keep the core idea and get rid of the biology.

Applying what you learn

"This is what we call extracting a design principle. The idea here is, obviously, we're not going to take a beetle exoskeleton and put them in your car. We want to learn how they're doing what they're doing, and we want to leave the biology behind."

The end result of this entire process is a relatively short document with abstracted design principles. This is in parallel with your other research, he notes, and now you're ready to start with your design. That process is now informed by these design principles.

"If you've done the biomimicry well, these design principles are succinct, technically accurate, and very appropriate to the functional challenges that you're trying to solve. That's really where the magic happens here. The magic is in the translation."

We all have problems to solve. So many of them have answers that are out there, if we can learn how to ask the right questions. "Next time you have a particularly sticky design problem," suggests GaleWyrick, "think about asking a biologist."

– By Robert Grace



Planet Earth hosts an estimated 30 million species, some of which have been evolving for 3.8 billion years. Humans can learn a lot from them when it comes to design, engineering, and problem solving.

Seth GaleWyrick photo, courtesy of Unwhirl.com



TECHNICAL



CONFERENCE

The Society of Plastics Engineers (SPE) Thermoset Division will host the annual Thermoset Conference at the Alexander in Indianapolis, IN. This event will connect all members of the thermoset material supply chain - from additives and chemicals to resin and reinforcement suppliers, compounders, processors and OEMs. Experts from the industry's leading firms will deliver updates regarding advancements in both 'virtual' and 'actual' thermoset processing techniques. This event will showcase over 25 methodologies, material developments and applications. In addition, trends in cross-linking compounds and raw material demand will be discussed. Guest speakers will illustrate global demand in newly emerging markets, as well as what areas within the United States are 'hot spots' for engineered compounds - and incentives out there for companies looking to expand their footprint.

Technical topics will be complimented by contemporary application case studies and market development tutorials focused on the pursuit of profitable, organic growth. Sponsor supported reception will provide educational and network opportunities. Exhibit spaces and sponsorship opportunities are available.



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