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Editorial

Exploring a dialectic approach to the challenges of translation from biology to technology or vice versa is the stuff of our latest opinion piece by bio-inspired design sage Julian Vincent, who advocates for "tradeoffs" as the linchpin between the two worlds and key to a common language and assessment.

Tradeoffs are unavoidable currently when it comes to protecting oneself from the sun with commonly available sunscreens. While most of these products might protect from damaging rays, they have been found to have health risks and cause environmental damage. Our case study explores how corals might just show the way toward safer sunscreens for humans and coral reefs, too.

Ryan Church, Rachel Hahs, and Norbert Hoeller cap their three-part series on the practicalities of introducing bio-inspired innovation to the world. Part three explores commercialization and the scaling up of companies, using examples from wind power, green chemistry and land use planning. The series has brought readers from ideation to business model development and market entry to commercialization.

Heidi Fischer takes us out into the desert again, this time to track rattlesnakes, and reveals some of the fascinating secrets of these exceptional survivors, including new insights into their "water harvesting" behavior. Leila Jeffreys, in our artist portfolio, shares her loving portraits of birds, specifically doves. A new book by Taryn Mead on the application of bio-inspired design to business management is reviewed by Daniel Weihs, Karen Verbeek, and Norbert Hoeller.

Finally, an interview with David Waggonner of Waggonner and Ball Architecture/Environment provides insights on his Living with Water project in floodprone New Orleans, expanding on the land planning example in "Stories from the Trenches."

We hope you enjoy this issue, and if you do, please avail yourself of one of our new features. At the end of each article, you can let us know what you like or don't by clicking on the thumbs up or down symbols, which will take you to a one-question survey. We really want to know! Happy reading! ×

Tom Noce+

Tom McKeag, Norbert Hoeller and Marjan Eggermont

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Sea anemone Photo: Ryan Poplin, 2007 | Flickr cc

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Fun in the Sun Tom McKeag

How corals might provide the answer for their own protection from harmful chemicals

It's summer in the northern hemisphere right now...and it's really hot. Hot like it's never been before; records have been set in places around the globe this year: Burbank, CA (114 degrees F), Montreal, Canada (97.9), Glasgow, Scotland (89.4), and most historically, off the coast of Oman, where the temperature had stayed above 108.7 for 24 hours. The Goddard Institute for Space Studies at NASA predicts 2018 will be the fourth hottest year on record since 1880, with the previous three years being worse. 2018 could still match the record, despite not being an El Nino year (1). In the continental United States extreme weather events are becoming more frequent as the jet stream becomes more undulating in its path and slows down, bringing intense weather, be it dry or wet, for longer sustained periods. The more sustained radiation from the sun has another implication besides lingering heat and subsequent drought: it is an increasing threat to personal health.

This type of radiation is what damages the cells in your skin when you tarry too long at the beach or fair and come back with a sunburn. No longer considered just a source of temporary pain and embarrassment, getting sunburned, particularly when one is young, has now been associated with incidences of skin cancer. World skin cancer rates are on the rise: 132,000 cases of melanoma and 2 to 3 million cases of other skin cancers occur each year, according to the World Health Organization (2).

Skin cancer is the most common form of cancer in the U.S., and its most dangerous form, melanoma of the skin, claims an estimated 10,000 lives per year. Melanoma of the skin are cancerous growths that develop when the sun damages DNA in skin cells, triggering mutations which multiply rapidly and form malignant tumors. These tumors originate in the pigment-producing melanocytes in the basal layer of the epidermis. It is most often caused by ultraviolet (UV) radiation from the sun of the duration that will give you a sunburn. UV radiation comes in three basic ray wavelengths: UV-A, B, and C, from longer to shorter wavelength (400-100 nm). Our atmosphere blocks virtually all of the shorter wave UV-C rays, and most of the UV-B, but the shorter the wavelength the more damage it can do, although it will not penetrate as deeply into material like one's skin. The type A (315-400 nm) and B (280-315 nm) rays are therefore of most concern for personal health.

Mr. Clean (Spotted Cleaner Shrimp hiding among giant caribbean anemone) | Photo: Laszlo Ilyes, 2010 | Flickr cc

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Fun in the Sun

Tom McKeag

To be out in the sun without incurring this damage takes some precaution, and one of the items that people turn to most is sunscreen, that sweet-smelling concoction of moisturizers, fragrances, and active chemical ingredients. Sunscreens block the sun in one of three main ways: chemical filtering, physical blocking, or a mixture of both. Chemical filtering is achieved by the use of organic molecules that absorb harmful UV rays and dissipate it as heat. Physical blocking is achieved by the scattering of the light by the use of inorganic minerals like titanium dioxide. Sunscreens are chosen as some of the prime preventive weapons against skin damage from the sun, helping to fuel a \$1.95 billion market for sun care products in the U.S. in 2016 (3).

These sunscreen formulations have been under scrutiny for both inadequate protection and harmful effects. They often contain the substance oxybenzone, and a type of vitamin A, retinyl palmitate, that may actually harm, rather than protect, skin. Oxybenzone (also known as benzophenone-3) is an allergen and hormone disrupter that soaks readily into the skin, and can be found inside virtually all Americans (97%) according to the U.S. Centers for Disease Control and Prevention



Oxybenzone Image: molview.org (4). A recent study by the Environmental Working Group found oxybenzone in twothirds of the chemical filtering sunscreens surveyed (5).

Beyond the potential threat to human health, these substances have been shown to be hazardous to the marine environment. Most chemical UV filters are, by design, stable non-biodegradable molecules that remain persistent in the environment. Many are lipophilic or fat loving, meaning that they are readily taken up by living tissue of fish, dolphins, and birds. They have been linked to disruption of the coral reef ecosystem, affecting algal growth, trophic levels, the carbon cycle, and the coral structure itself (6).

This is of concern because the reefs that corals build are some of the most important marine ecosystems on earth, providing habitat for approximately one quarter of all marine species. They are under widespread threat from the growing acidification of the oceans caused by the burning of fossil fuels and the increase in CO₂ in our atmosphere. Oceans absorb up to 30% of the CO₂ we produce, and this reacts chemically within the water column making carbonate ions less available for coral and other species to construct their exoskeletons (7).

The animals that make up corals are anthozoans, a class of invertebrate within

the phylum Cnidaria, which includes a diverse assortment of creatures like jellies, hydroids, and sea anemones. In this mostly marine and entirely carnivorous club you can either float or anchor yourself to a surface, and many do both within their lifespan.

When corals anchor themselves, they do so as attached polyps in large colonies, and they do it by using calcium carbonate, or lime, as a cement. The Great Barrier Reef along Australia's northeastern coast is a huge collection of these colonies, built on the 10,000-year-old ruins of their ancestors' exoskeletons.

The carnivorous corals can't go it alone, so they have co-evolved with an algal boarder, a paying house guest who supplies most of their energy needs through photosynthesis. These are unicellular dinoflagellates in the genus Symbiodinium, known as zooxanthellae. The algae are there for the same reason as everyone else: clear, calm, and relatively warm water. For their tithing of sugars, they receive the shelter and protection of the corals' limestone fortress. They also receive a daily nutritious dose of nitrates and phosphates from the corals' waste. While this mutualism is beneficial to both parties, it isn't entirely unforced. The corals excrete a digestive solution that causes the algae cell walls to

Giant clam mantle tissues act as a habitat for the symbiotic single-celled dinoflagellate algae (zooxanthellae) from which it gets its nutrition. By day, the clam spreads out its mantle tissue so that the algae receive the sunlight they need to photosynthesize. | Photo: pierre pouliquin, 2007 | Flickr cc

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Ceratium hirundinella (Dinoflagellate) Image: Ernst Haeckel (1834–1919) | Wikimedia Commons

leak their precious food. It's estimated that 80-90 percent of the algae's sugars go to the corals. An entire ecosystem is based on this symbiotic relationship that translates the energy of the sun into the building of a massive underwater world.

Corals are extremely sensitive to small changes in the magic formula that makes up their habitat. Even slight changes in temperature, salinity, light, and nitrogen can kill them outright. It has been estimated that 90% of all coral reefs will be at risk by the 2030's (8). How we reduce and reverse the air pollution that is causing climate change will be critical to the survival of these shallow seas ecosystems. Reducing more local threats like direct poisoning is also important.

Government bodies, including the Environmental Effects Panel of the United Nations Environment Programme, have recently expressed concern about this environmental toxicity and human health issue, and the European Chemicals Agency included half of the sixteen UV filters most used in Europe in its recent Community Rolling Action Plan. Legislators in the State of Hawaii have passed a bill (now signed into law by the governor) banning the chemicals oxybenzone and octinoxate from sunscreen products because of growing concern about health, aquatic toxicity and damage to coral reefs. They have been concerned since 2016 that all those visitors to the marine wonders of the Hawaiian Islands are spreading these compounds into the water column and harming the creatures that live there and the ecosystem that they comprise.

Ironically the very organisms that appear to be threatened by the effects of these sunscreens may provide clues for safer alternatives. Dinoflagellates, and over 380 other marine organisms (animals, algae, and cyanobacteria) produce what's known as mycosporine-like amino acids (MAA's) in their exoskeletons or skin and these compounds could be safer sunblocks.

MAAs are a family of 30 known compounds that act as secondary metabolites. It is currently believed that their primary function is photoprotection. They comprise a core cyclohexenimine or cyclohexenone ring chromophore that is bound to an amino acid residue or its imino alcohol. They have conjugated double bonds which are believed to function as high-energy absorbers and heat dissipaters. MAA's are promising for a commercial application alternative to oxybenzone and octinoxate because they have a maximum absorbance in the UVA and UVB range (310-362 nm), have a low molecular weight (< 400 Da), are water soluble, and do not break down in typical levels of light and heat. They also act as antioxidants, scavenging reactive oxygen species (ROS) and suppressing singlet oxygen-induced damage (9). ROS are associated with UV radiation, subsequent DNA damage and photosensitivity disorders.

Exactly how the dinoflagellates produce these compounds is still being investigated, but has been described well enough in the literature for research to turn to applications (10). Several laboratories have learned enough about the biological production pathways to MAA's to investigate three paths to a safer sunscreen: culling the material from the wild, harvesting compounds from genetically altered organisms, and completely synthesizing the chemicals.

Paul Long and his colleagues at the Institute of Pharmaceutical Science at King's College London are extracting an MAA called palythine from the red algae *Chondrus yendoi*, and claim good results in protecting *in vitro* human skin



Cyclohexenone Image: molview.org

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Porphyra umbilicalis | Photo: Gabriele Kothe-Heinrich, 2012 | Wikimedia Commons

cells from intense UV-A and UV-B light at low doses, and also good antioxidant properties (14).

The Gelyma company (15) of Marseille, France, manufactures a wide array of natural bioactive skin care products including Helionori[®], a sunscreen and moisturizer made with an extract containing MAA's from the red algae *Porphyra umbilicalis*.

Yousong Ding is an assistant professor and medicinal chemist in the College of Pharmacy at the University of Florida, and he and his colleagues have been using a cyanobacterium to produce a MAA called shinorine. They have genetically engineered one species with the borrowed genes from another (Fischerella). Testing the shinorineoverexpressing Synechocystis cells, the researchers demonstrated greater growth under UV-B light compared to the unaltered Synechocystis cells, indicating the effectiveness of shinorine as a UV-B protector. Importantly, they were able to speed up the production of shinorine to a two-week cycle and a ten-fold increase in production of the material using this benign photosynthetic approach (11). Current commercial production relies on extraction of shinorine from a red alga, Porphyra umbilicalis, typically harvested from the wild, so this has commercial sunscreen manufacturers interested.

Gadusol Laboratories is a company formed at Oregon State University that uses a genetically engineered yeast to produce gadusol, a compound very similar in structure to MAA's. Researchers led by Taifo Mahmud had investigated zebrafish eggs which contained gadusol, and thereby discovered that the fish contained the gene for its production, rather than acquiring the sun-protecting substance from their diet as previously thought (12). Moreover, they devised a way to splice the fish gene into yeast for the purpose of production. The company is currently working toward boosting yield from their yeast strain.

In a different approach, a team at the University of La Rioja is synthesizing compounds based on computer analog models. Using a template compound of aminocyclohexenimine, they were able to demonstrate boosted performance in blocking UV-A and UV-B rays by commercial



Gadusol Image: molview.org

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Sunscreen UV-15 Image: molview.org sunscreens that had been doped with the compound (13).

While there is active research and development interest in these naturally and synthetically derived MAA's, and the potential commercial rewards are high, bringing them to market, especially in the U.S., is not for the faint of heart. The European Union considers sunscreens cosmetics and has traditionally offered a wider range of consumer choice in sunscreens (both for good and ill), but the U.S. classifies sunscreens as drugs and therefore regulated by the U.S. Food and Drug Administration (FDA). The time and expense needed to gain FDA approval is daunting and a clear deterrent for companies with shallow pockets and any uncertainty about large profits. Still, inroads are being made, and like many technology improvements, wider adoption of safer chemical UV filters based on living organisms will likely be a result of the convergence of consumer demand, regulatory pressure, and advances in production scaling.

Whether humans capitalize on these sun-protecting chemical compounds or not, one can be sure that the organisms that employ them will continue to evolve under accelerated climate change conditions. Meanwhile, they may just help us help them to survive.

Footnotes

1. <u>https://www.nytimes.com/2018/08/09/</u> climate/summer-heat-global-warming.html

2. <u>http://www.who.int/uv/faq/skincancer/</u> <u>en/index1.html</u>

3. <u>https://www.grandviewresearch.com/</u> industry-analysis/us-sun-care-market

4. https://www.cdc.gov/nceh/

5. <u>https://www.ewg.org/sunscreen/report/</u> executive-summary/#.W3cNHS2ZMqI

6. Lawrence, K. P., et al. "Molecular photoprotection of human keratinocytes in vitro by the naturally occurring mycosporine-like amino acid palythine." *British Journal of Dermatology* (2018).

7. <u>https://oceanservice.noaa.gov/facts/acidi-</u> fication.html

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12. Osborn, Andrew R., et al. "De novo synthesis of a sunscreen compound in vertebrates." *eLife* 4 (2015): e05919.

13. Losantos, Raúl, et al. "Rational design and synthesis of efficient sunscreens to boost the solar protection factor." *Angewandte Chemie International Edition* 56.10 (2017): 2632-2635.

14. Lawrence, K. P., et al. "Molecular photoprotection of human keratinocytes in vitro by the naturally occurring mycosporine-like amino acid palythine." *British Journal of Dermatology* (2018).

15. <u>http://www.gelyma.com/products/sun-</u> care.html

We would appreciate your feedback on this article:







Hub Photo: Beige Alert, 2010 | Flickr cc

Article **Stories from** the trenches of biomimetic innovation: Commercialization & Scaling Up Ryan Church, Rachel Hahs, & Norbert Hoeller

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Stories from the trenches of biomimetic innovation: Commercialization & Scaling Up Ryan Church, Rachel Hahs,& Norbert Hoeller

In the first two articles of this series, we talked about ideation and proof-of-concept, along with business model generation and a correct market entry strategy to bridge the Valley of Death (VoD) in the road to innovation. Many companies flounder trying to cross the valley, due to a lack of capital, innovation, product-market fit, time or people to execute. In many cases, it is a combination of factors, but having the right team to execute on the business model is perhaps the main reason why some companies and technologies make it, and others do not.

Wind Energy

As we discussed earlier, the wind industry has specific challenges that must be identified and planned for. In this section, we will examine the two case studies we have been tracking - WhalePower and Biome through their commercialization efforts and strategies in scaling up, and getting their respective technologies to market.

WhalePower

In the previous article, we explored WhalePower's decision to test their tubercle technology on a turbine platform that was not widely deployed or accepted in the market. Given the results of the test, the team struggled to pivot or execute on a modified business model. The team at WhalePower seems very heavy on research and development, but less so on business development, sales and finance, with no experience in the wind industry. Business development, sales and finance form the core of the execution phase in the VoD. Without these pieces in place (and executing effectively), the chances of success dwindle.

Even if WhalePower had completed successful R&D trials that would convince potential customers, financiers, and partners, it is uncertain whether the technology would have made it to market, given the general difficulty in crossing the VoD. The competition for good ideas is high, but the competition for good execution is even higher. WhalePower was able to shift their focus to other applications, such as ceiling fans, for which a licence was sold to Envira North Systems. However, their fateful decisions early on to design a better wind turbine blade led to an eight year dormancy for the technology in that application, until a world-wide licence was sold to Tubercle Engineering Group (TEG) in Germany in February 2016.

After TEG bought the rights to WhalePower, they dropped all references to performance gains on their website. Instead, TEG turned to the German Aerospace Centre

Wind turbine mast | Photo: brewbooks, 2009 | Flickr cc

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London Array | Photo: fkwiatkowski, 2014 | Flickr cc



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(DLR) to complete credible proof-of-concept wind tunnel testing. They found a significant reduction in uneven loading due to wind gusts, which could lead to increased reliability and improved profitability over the turbine lifespan - a strong value proposition. In May of 2017, TEG announced that they had partnered with Thermo Plus GmbH to retrofit a 2MW wind turbine at the Windtest Grevenbroich GmbH test facility, to see if a reduction in fatigue loads of 8% and a reduction in noise emissions of 2dB could be realized at scale. They claimed that they were confident that they could achieve these results "without increased resistance coefficients, which otherwise would have reduced the yield in the later operation of [the wind turbine]." TEG markets a retrofit solution for active turbines in the field, meaning they do not need to deal with the large conglomerates that generally dominate the industry. This understanding has, in part, enabled them to reach the finals of the Northern Bavaria Business Plan competition. Their team is also well balanced with R&D, business development, and sales, with specific expertise in wind energy development, and former senior leadership positions at ABB and Siemens.



Siemens blade Photo: Chris Bentley, 2017 | Flickr cc At the time of writing, it is unclear whether these planned pilot trials took place. However, with the right approach to market entry, business plan development, and team, TEG has progressed further in two years than WhalePower did in over a decade. This demonstrates that execution is often more important than ideation. The ability to execute is what gets technology to market.

PowerCone

In the previous article, we explored how Biome championed a triple-bottom-line business model that sold fully-installed PowerCones directly to wind turbine owners. We looked at how they created an ecosystem of partnerships to bring in sector-specific expertise, which in turn meant that success for the PowerCone meant direct success for a sizable portion of the industry. Biome's business model and market entry strategy revolved around a co-creative exercise that reached customers directly to explore their pain points, and what was desirable or even feasible from a business perspective. Through this methodical approach, Biome succeeded in inking partnerships with Capstone Infrastructure, a large Independent Power Producer (IPP),



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composite manufacturers, and numerous other service providers who would be involved not only in the pilot test of the PowerCone, but also in its follow-on ability to scale up quickly. With funding in place, now it was time to execute.

Manufacturing a PowerCone is no small feat. The PowerCone has three blades that extend out about 10 meters from the centre axis, being bolted to the solid cast hub. Biome conducted a lengthy search before choosing their manufacturer. They decided part way through the venture that they would not be manufacturing the PowerCone - at least, not right away. Finding a large amount of specialized shop space that is suitable for the job is hard to come by, so it is best to partner up - nature employs this symbiotic principal all the time.

"It's a very complex process," recounts Kien Lamson, Head of Product Development. "It's good to work with people who have done it before. Composites are more art than science." This strategy also allows Biome to scale quickly if the pilot is successful.

As the focus of Biome shifted from fundraising to executing on the full-scale pilot, Biome continued to attend industry events such as the American Wind Energy Association (AWEA) and its Canadian equivalent (CanWEA), speaking about the

PowerCone and meeting potential customers (and future talent) first hand. It was during these events that Biome was able to meet, and later attract senior wind industry talent that it needed to help execute and prepare the company for commercialization. At the same time, Biome had a chance to communicate the traction it was getting in the marketplace, helping to fill the funnel, which would ensure that if the pilot was successful, they would have initial customers. A lot has been written about this in sales strategy, but the underlying concept is to make sure you attract enough interest, such that even if only a small percentage of those convert, you are on your way to business success. This duality of attracting customers and talent from the same pool makes strategic sense in the wind industry because it is such a tight-knit community. Once word gets out that a credible technology is coming to market, it doesn't take long for word-of-mouth to spread the message. Credible customers such as Enbridge, Capital Power and EDP Renewables are a few of the customers who expressed interest during this period.

In speaking to these customers, one theme predominates: data. After Biome introduces the ideation story and business model, customers always want to look at the data. Biomimicry is not something that customers dwell upon. It helps to answer the question, how come you solved it when no one else has, but not much beyond that. At the moment, Biome is executing a fairly rigorous engineering plan that would be recognizable to many in the industry. Biomimicry plays no part of it. Instead, it's all about execution to complete the pilot successfully, on time and on budget. "We may never have gotten here without biomimicry," recounts Church. "But now that we're here, we need to rely on the tried and true method of business operations and old fashion execution. Biomimicry is the secret sauce that makes Biome tick, but it's under the surface, nascent." For Biome, biomimicry is mainly at the front end of ideation, design and innovation. It makes an appearance elsewhere in the company through leveraging symbiotic networks and in the business model, but it's not what Biome relies on to get the job done. The PowerCone is due to start full-scale testing in the fourth quarter of 2018.



Silk friend Photo: Jeff Pyle, 2008 | Flickr cc

Stories from the trenches of biomimetic innovation: Commercialization & Scaling Up Ryan Church, Rachel Hahs,& Norbert Hoeller

Green Chemistry

Molecular Heat Eater, Trulstech, Inc. As discussed earlier in this series. Mats Nilsson's use of biomimicry in his innovation process to create a completely eco-friendly flame retardant delivered just that - a non-toxic biodegradable alternative to conventional flame retardants that represents a potential paradigm shift in the industry. The potential for impact of MHE[®] is wide-ranging, with significant human and environmental health benefits including a complete disruption of the raw material supply chain - MHE®'s raw materials come from food. But as Nilsson has discovered, generating a paradigm-shifting solution turns out to be only half the battle. Generating a successful business strategy that navigates the system challenges presented by a revolutionary idea can be much harder.

Realizing that Trulstech's main strengths were in research and development (R&D), Nilsson has pursued a strategy of finding partners interested in buying the rights to produce and sell the flame retardants with R&D support from Nilsson's company Biomimetic Technology, Ltd. (BT). Nilsson has secured patents for the flame retardant technology in regions around the world, and has since been focusing his efforts on finding partners in regions where drivers such as stricter regulations on hazardous chemicals in flame retardants might incentivize manufacturers to switch to MHE[®]. Deflamo AB (https://deflamo.com), a startup in Sweden, was the first company to buy the rights to produce the flameretardant in Europe in 2004, where stricter hazardous chemical regulations have necessitated an industry shift away from many conventional flame retardants. With support from BT. Deflamo has received certifications from accredited laboratories for the flame retardants (under the name Apyrum) on various host materials under European fire safety standards.

However, despite the promise of the flame retardant technology and proven effectiveness at a competitive price, Deflamo has been slow to grow. Over the last decade, its stock price has dropped to near zero from a high of around 30 Swedish krona (SEK) in 2009. Since 2004, Deflamo has experienced several management changes resulting in changing strategies and varying technical skills and market knowledge. In addition, according to the Deflamo website (https://deflamo.com/ en/corporate governance/styrelse/), the Directors and company management have expertise in entrepreneurship and business growth, but none appear to

have a background in chemistry or the flame retardant industry. In 2016, Deflamo executed on a plan to bring all laboratory work in house and terminated the laboratory support provided by BT. According to Nilsson, the staff chemists they did hire did not have the background required to fully take R&D for Apyrum in house. In addition, Deflamo decided to narrow the company's focus to one host material application, PVC, which may be too limited of a market segment to drive sufficient income. Thus, while the technology has been proven, the lack of growth in a European market, where an increasing number of regulations restricting the use of hazardous chemicals like halogens should benefit a company like Deflamo, suggests that one reason for their failure may be that business execution has been lacking.

Nilsson's experience in trying to get MHE® into the market - pursuing large manufacturers whose purchasing discounts through large chemical manufacturers disincentivized them from using MHE®; sinking significant resources into extensive R&D in partnership with Deflamo without significant returns; trying to convince skeptical engineers and chemists that the MHE® technology was viable despite the fact that it didn't resemble anything on the market - has led Nilsson to try different tactics in different markets with different partners.

One such partner is Elena Ayers, a marketing professional in Canada. While Nilsson had originally targeted large manufacturers, Ayers is looking to smaller segments of the fire retardant market, including targeting startup manufacturers looking to differentiate themselves with eco-friendly products that require flame retardants, and the Canadian government which is struggling to deal with the increasing threat of the intensity and frequency of forest fires combined with a limited budget. Ayers determined that targeting smaller segments of the market is advantageous for several reasons.

Pursuing partnerships with startup manufacturers targets a segment of the market that may be more open to new technology that can create greater market differentiation from the start. Startups or small businesses might also be in search of outside resources to get off the ground and scale up. With her partnership with Nilsson, Ayers will be able to customize MHE® to the product's relevant host material(s) at no cost to the manufacturer, significantly reducing the risk for the manufacturer and creating a win-win scenario at the point of certification for meeting relevant fire safety standards. In addition, according to

Smoke From Canadian Wildfires Drifts Down to U.S. Photo: NASA Goddard Photo and Video, 2015 | Flickr cc



Ayers' discussions with Ontario's Ministry of Natural Resources and Forestry representatives, the agency is struggling to come up with a viable solution that is cost effective and non-toxic for both firefighters and the environment, resulting in perhaps a greater openness to trying a new technology and moving ahead with field tests.

Entry into the market requires certification by an accredited laboratory that the flame retardant meets relevant fire safety standards (certifications do not transfer from Europe to North American markets). Certification is an expensive proposition, so starting small by working to get certification for one host material enables relatively smaller upfront investment while also proving the viability of the technology and gaining additional interest in investment in the company and products. In targeting a government agency, Ayers hopes to leverage government grants to complete the required government testing.

Finally, while one of the truly revolutionary impacts of MHE[®] is a raw material supply chain that relies on products in the food industry, such as byproducts of foods like grapes, the reality is that this supply chain does not exist today. Setting up that supply chain would likely take time and resources that would further delay entry into markets around the globe. Therefore, Nilsson and Ayers recognize that while MHE[®] represents the potential for a complete paradigm shift in production of flame retardants in the long-term - including local procurement of raw materials at the location of manufacture around the world - the immediate goal of getting MHE[®] established in the market in the first place necessitates that in the short-term, MHE[®] may need to be produced with inexpensive raw materials that exist in the food industry's supply chain today (e.g., synthetic citric acid) to lower the barriers to entry for MHE[®].

As indicated in previous articles, the flame retardant industry is well established with incentives in place to maintain existing supplier-customer relationships, pricing structures, and a strong lobbying system to influence government regulations and the public. Against this backdrop and despite frustrations, Nilsson continues to push forward with his technology with the strong belief that the potential benefits to humankind and the planet are worth the struggle. As Ayers and Nilsson hone their approaches to establishing MHE[®] in global markets, the lessons learned from their experiences are important for other biomimics with gamechanging ideas and scant industry-relevant business experience. They have moved beyond trying to sell the technology on its

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merits alone. To help break down barriers to entry, they are:

- breaking down the value proposition of the innovation into short- and longterm business strategies including using existing technologies and resources to create a price competitive product in the short-term,
- aligning the technology value propositions with market drivers to identify the right entry points into the market,
- and identifying market incentives that enable the targeting and creation of win-win partnerships.

The Built Environment: Living with Water

The previous article in this series (https:// zqjournal.org/editions/zq22.html p. 8) described research in restoring and regenerating the Mississippi delta. However, the residents of New Orleans and other lowlying areas of Louisiana suffer from flooding today, not only from hurricanes like Katrina in 2005, but also high tides and intense rainfall due to the subtropical climate. The Union of Concerned Scientists identified 91 communities in the USA that suffer from chronic inundation where 10% of usable land flooded 26 times or more per year – of these, 59 were in Louisiana ("Louisiana Faces



New Orleans has developed with water out of sight and out of mind. Photo: Ramiro Diaz
Chronic Inundation," 2017). The problem will only get worse with rising sea levels, land subsidence, and increasing storm intensity.

The traditional solution has been levees and floodwalls that keep the rising water out, but also keep rainwater in. The constant need to channel and pump water has led to a vicious cycle, causing land subsidence of up to 2.4 meters (8 feet) such that much of New Orleans is now below sea level, further increasing the need for pumping. Following Hurricane Katrina, Waggonner & Ball Architecture/Environment (http:// www.wbae.com/) proposed a way for New Orleans to "reinvent itself as a safe, resilient, economically vibrant city that embraces its life-blood: water" ("Living With Water," 2016), engaging the community and local expertise to move beyond concerns about safety to community resilience. Living with Water encompasses a movement in New Orleans, catalyzed through the Dutch Dialogues and the Greater New Orleans



Dutch Dialogues concept for a regional approach to water infrastructure that returns multiple benefits: safety from flooding, integration with stable geologic "backbones" that structure the land, and increased quality of life for man and nature.

Source: Waggonner & Ball

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Urban planning processes must build on deep structures of place, beginning with soils, water, and biodiversity. Source: Greater New Orleans Urban Water Plan Urban Water Plan, and continuing today through the firm's advocacy and project implementation. Additional background information can be found in David Waggonner's interview in this issue.

The Dutch Dialogues

The "Living with Water" initiative (<u>http://</u> <u>livingwithwater.com</u>) officially started with a Louisiana delegation led by Senator Mary Landrieu visiting the Netherlands in 2006. Based on observations of Dutch water management in situations similar to those in New Orleans, Waggonner & Ball convened three Dutch Dialogue workshops from 2008 through 2010 in collaboration with the Royal Netherlands Embassy and the American Planning Association that brought together a wide range of experts from the Netherlands and the USA to



Dutch Dialogues concept drawing for increased water storage and recreational space along the London Avenue Canal. Source: Waggonner & Ball

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Current

Proposed

Urban surfaces, including streets and parking lots, are paved with impervious materials that shed stormwater directly into storm drains and prevent that water from soaking into the ground.

Underground pipes and culverts are often overwhelmed by stormwater, causing backed-up storm drains to overflow into streets. These pipes do not allow stormwater flowing through them to infiltrate into surrounding soils.



Slow

Rooftops, driveways, streets, and sidewalks can be redesigned to catch rain where it falls, and to allow some of that water to soak into the ground. A healthy urban tree canopy also slows the flow of water and improves environmental quality.

Store & Use

Large-scale detention and retention features integrated into canal networks and public spaces provide additional storage capacity. Stored water can be used for irrigation, recreation, and other purposes.

Current and proposed stormwater management strategies within the perimeter levee system. Source: Greater New Orleans Urban Water Plan



Pump

Fed by drainage pipes and canals, powerful pumps at the perimeter of each basin lift stormwater over the levees into Lake Pontchartrain, the Inner Harbor, and the Central Wetlands Unit.

umps



Drain When Necessary

Pumping should not be the only solution for managing stormwater. Slow & Store features lessen loads on pumping stations, provide additional factors of safety, and enhance the capacity of drainage systems overall.

develop an integrated, multi-scale approach to water management.

A grass-roots coalition of stakeholders and local/international experts participated in intensive design sessions that brought together previously siloed or overlooked information about the natural landscape, the urban fabric, and the drainage infrastructure. The results were presented and debated with the affected communities and municipal departments. Rather than trying to change the existing governance structure, the Dutch Dialogues created an informal and independent civic process that built public support for a new vision founded on knowledge of the natural environment, the history and culture of New Orleans, existing infrastructure, and the needs of New Orleans' communities. Dutch Dialogues ideas were refined and expanded through the Greater New Orleans Urban Water Plan, which added support from local and regional institutions and was ultimately incorporated into the city's official resilience plan.

The Dutch Dialogues created a knowledge base for the Water Plan, a living document based on five key principles:

Slowing and storing storm water, and pumping as a last resort

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Dutch Dialogues conceptual proposal for water storage parks within unused urban spaces. Source: Waggonner & Ball

- Improving surface water quality and balancing groundwater levels to limit subsidence
- Building with nature
- Designing for adaptation
- Working together

The Dutch Dialogues model continues to be refined in other U.S. cities. Supported by an international network of experts, workshops have been held in New York, Bridgeport, St. Louis, Tampa Bay, Los Angeles, and most recently, Norfolk (Virginia). The Norfolk/Hampton Roads area shares many of the same challenges as New Orleans due to subsidence and above average sea level rise, and exemplifies the benefits of sharing knowledge across communities and regions (Anderson, 2017).

The Greater New Orleans (GNO) Urban Water Plan

In the 19th and into the early 20th century, New Orleans was recognized for how its public spaces featured water, but as wetlands and swamps between the Mississippi River and Lake Pontchartrain were drained to promote urban growth, water took on another threatening dimension. New Orleans is not only vulnerable to hurricanes but also receives an average of 1592 mm (63") of rain annually, with rain storms often dumping 100-200 mm (4-8") in a few hours. The short-term focus on "drainage first" led to the expansion of elevated and walled outflow canals that cut through neighborhoods, isolating communities and further separating people from the water.

During the Katrina recovery, New Orleans lacked an integrated design strategy that addressed water and the physical landscape at the scale of individual lots, neighborhoods, the urban landscape, and regional infrastructure. The GNO Urban Water Plan is a long-term, 50-year plan that address all these scales and brings together hydraulic engineering, urban/landscape design, and governance. It is integrated, proactive, adaptive, and delivers a broad range of functions and values by reconnecting patterns of land use with fundamental qualities of the ground and natural systems.

Federal funding supported development of a master plan for a "healthy and balanced water system, which really works in wet and dry periods" (Waggonner et al., 2014, p. 16). This occurred through three interventions: delaying the flow of stormwater, storing and using water, and only pumping water when necessary. Models suggest that these interventions will allow New Orleans to avoid heavy flooding, although particularly





Blue Green Corridors and Outfall Canal retrofits are project proposals within the Gentilly Resilience District. Source: Waggonner & Ball

vulnerable areas may experience some shallow flooding during 1-in-10-year storms, while stabilizing groundwater to limit further subsidence.

The plan replaces flood walls with green canals, water parks, and urban forests that slow water flow and help replenish groundwater. City edges (beaches, marshes, river and lake sides) are upgraded and connected through blue-green urban parks and public transit to create visible and accessible recreational spaces. At the district/neighborhood level, the plan provides a toolbox of interventions tailored to seven distinct types of urban fabric that improve community life and create opportunities for economic development. This place-based approach recognizes and creates space for diversity, one of the foundations for successful and resilient systems.

The GNO Urban Water Plan has been evaluated in terms of reduction in the costs associated with flooding and subsidence, as well as the positive benefits of urban investment, community improvements, and job growth. It takes a systems approach that can be communicated to different stakeholders by working at multiple scales in multiple domains. The City of New Orleans was recently awarded \$141 million through the U.S. Department of Housing and Urban Development (HUD)'s National Disaster Resilience Competition (NDRC) for their proposal to implement the Gentilly Resilience District, a concept first proposed during the Dutch Dialogues and developed in greater detail in the Water Plan. The project is a tangible example of working with nature to deliver long-term financial, economic, social, and environmental benefits for a broad range of stakeholders, helping heal the relationship of resident to water and making water a crucial part of the New Orleans' landscape again.

Observations

- Identify a specific target that has a compelling need for the solution, determine the pathways required to deliver the solution at a competitive price, and build a team with the necessary expertise to turn the prototype into a viable commercial product or service. This stage is all about execution.
- Limit the scope of the solution to meet the essential needs of the target. Biology typically solves more than one problem at a time, which can lead to paradigm-changing ideas. However, systems are resistant to change - trying to disrupt them can significantly raise the barriers to entry. Additional value can be added once the benefits of the

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solution are recognized and in use by the target.

- Look for targets in other sectors who have compelling needs for the solution to demonstrate the general applicability of the solution and diversify revenue potential.
- Assess the kind and level of investment needed to be commercially successful. Novel solutions that are perceived to be risky may benefit from a diverse in-house team, or a tightly integrated ecosystem of partnerships.

Series Summary

This series of articles explored a few examples of biomimetic innovation from ideation and proof of concept, through business model and market entry strategy, and finally commercialization and scale-up. The first stage emphasized the problem/solution domain, requiring a deep understanding of the problem and identifying novel and effective solution pathways. The second shifted to the application domain through identifying a tangible and unmet need where the solution delivers significant value. The final stage focuses on identifying and satisfying a specific target customer that has a compelling need for the solution. It may involve broadening the focus to include the systems implications of solutions delivery and implementing a plan of execution that includes short-, medium- and long-term goals. This stage often requires building a team with diverse skills to address roadblocks to commercialization success.

The degree of biomimetic influence in our case studies tended to be strongest in the ideation stage, which is to be expected as the later stages of the projects concentrate on technological challenges and business execution. There are biomimetic aspects in the Dutch Dialogues and development of the Urban Water Plan: an emphasis on place-based solutions, engaging a diverse set of stakeholders, and addressing a wide range of economic/social/environment factors. Many products or services can benefit from understanding the broader systems implications and opportunities of the innovation. As we try to tackle more complex problems, relationships and interactions become increasingly important. In the Building with Nature examples, creating the network of relationships within the stakeholder community was the solution, since the team is very much a part of the ecosystem intervention. Diverse professional expertise is essential for collaboration but can also create barriers - raising the level of discussion can create "... opportunities for people to think more holistically

about their impact on the environment, and their environment's impact on them" (Waggonner interview in this issue).

Our article series focused on the efforts of a small segment of the biomimicry innovation community. To gain a deeper understanding of lessons learned and pathways to success, we want to start a dialog based on this series by opening the next article up to additional perspectives and experiences. If you are interested, please contact us at stories@zqjournal.org.

We would appreciate your feedback on this article:



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Stories from the trenches of biomimetic innovation: Commercialization & Scaling Up Ryan Church, Rachel Hahs,& Norbert Hoeller

Ryan A. Church is the Founder and CEO/CTO at BiomeRenewables Inc., where they are developing biologically-inspired renewable energy technologies. They are launching in the wind industry with the PowerCone, an enhancement technology that enables nine world-firsts in the wind industry with initial indications suggesting that this technology could break the Betz Limit while decreasing turbine loading. He has given university lectures and advised governments in both Canada and Europe as a thought-leader in the field of renewable energy and biomimicry. Recently, Church was nominated as a Forbes 30 under 30 in Energy.

Rachel Hahs is a Certified Biomimicry Professional focused on driving life-centered, economically sound sustainable design solutions in strategy, innovation and systems. Building on 13 years' experience in sustainability consulting for public and private sector clients, she consults, researches and writes about how biomimicry in innovation can result in disruptive innovations with cascading system impacts that will accelerate our transition to a sustainable future.





River Amstel, Amsterdam | Photo: M. Eggermont, 2018



Untitled (New Caledonian crows) Photo: Jolyon Troscianko | <u>www.jolyon.co.uk</u>

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Opinion What did Socrates ever do for you? Julian Vincent

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What did Socrates ever do for you? Julian Vincent

The central problem in biomimetics is how to bridge the gap between technology and biology. We can define this target in general terms as follows: we need to produce one kind of theory (e.g. biological theory) that can work in the context of another (e.g. engineering or design theory), and vice versa. If we could do this in such a way that the resulting pair of theories were mutually inverse, then we would have grounds for saying that they were equally general. If we could say one and not the other, we could rank one theory more general than the other. If we can say nothing at all, then the generality of the two theories cannot be compared - they are of different generality. Viewed like this, biomimetics currently falls into the second category. This is because much, though by no means all, of biology can be explained with physics, engineering and chemistry, but it less easy, or possible, to explain physics, engineering and chemistry in terms of biology. So the two theories combine only partially.

In this essay I propose that if both biology and technology can be shown to have their problems described - or even defined - as trade-offs, we have common ground for the two and can raise biomimetics to the first of the categories described above. This opens up the possibility of negotiation and agreement, after which the exchange of gifts is a formality!

Everything we do and are involves trade-offs at multiple levels. 'Trade-off' is expressed in many ways - compromise, optimisation, choice, balance, negotiation and so on. But a trade-off does not represent, or result in, a static position or decision, which is how trade-offs are commonly approached by biologists. The tendency is to think that a trade-off has only one answer - the 'optimum'. But in an ever-changing world, the 'optimum' cannot afford to be static. The glory of the trade-off is that it is a mechanism for adaptation. Consider speed and accuracy, a trading pair common to both biology and technology. Do a task faster and you risk doing it less well. Do it more slowly and quality is likely to improve. The resolution of this trade-off can be achieved by practice, memory, learning, prediction and feedback. But whether you do something quickly or slowly depends in large part on the context of the action. Quickly when it's urgent, slowly when the accuracy of the outcome is more critical.

Although the first recorded use of the term 'trade-off' is only a little over 100 years ago (and it's not in Roget's Thesaurus) the concept has its origins with the Greek philosopher Heraclitus of Ephasus who said that everything is in constant change,



New Caledonian crow with a stick tool Photo: Jolyon Troscianko | <u>www.jolyon.co.uk</u>

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as a result of inner strife and opposition (unfortunately, Heraclitus never published his ideas formally). The concept was popularised by Plato's Socratic dialogues, that in order to establish a truth it is necessary to have two or more people with opposing views to engage in dispassionate discussion until a resolution is reached. This unity of opposites is known as the dialectic. In practical terms this equates to making a statement of some sort, questioning the statement with counter-arguments, then working towards some sort of agreed truth.

Over the years, many forms of dialectic have arisen: the one most familiar to Europeans is the Hegelian dialectic, although Hegel said that he got the idea from Kant. Kant named the two opposites thesis and antithesis, and the resolution he called the synthesis. The synthesis can then become the thesis in a new dialectic. This, however, is a formalism. As Karl Popper gleefully pointed out, advance is more likely to be made with the rather messy 'trialand-error' approach, much closer to Socratic dialogue. And trial-and-error is the basis of natural selection in biology, with genetic and phenotypic variations being exposed to the selection pressures of the environment, physical and biotic.





New Caledonian Crow probing for larvae with a stick tool Photo: Jolyon Troscianko | <u>www.jolyon.co.uk</u> What did Socrates ever do for you? Julian Vincent

But the trial-and-error of natural selection, whose product is evolution, is different from the Socratic and Hegelian versions of the dialectic in at least one major factor. Socrates could argue only about what was known, and Hegel's formalism was even more limiting. Natural selection works on variants of organisms that have some novelty about them, and the selection pressures are similarly lacking in control, although they may be circumscribed by context. Moreover, although 'trial-and-error' sounds like a scatter-gun approach (perhaps similar to Thomas Edison's approach to invention - workable, but it takes time and investment), an organism, with even simple sensory abilities, can often avoid the most extreme trials and so reduce the error rate. Scientific research is much the same - you may have an inkling of what the answer has to be but the journey you take to get there is unlikely to be direct. It is also very likely that your imagined end-point will turn out to have been illusory, and the new reality is more interesting and convincing than was initially conceived. In science, therefore,



New Caledonian Crow that has extracted a Cerambycid longhorn beetle larva from the deadwood using a stick tool Photo: Jolyon Troscianko | <u>www.jolyon.co.uk</u>

and especially in biology (biologists love surprises), the dialectic is not an appropriate model for research since at least half of the argument cannot be predicted since there is no coherent model that will support prediction.

But there is another problem with the Hegelian dialectic. Although in its ideal form merit is recognised in both thesis and antithesis and preserved in the synthesis (an example is the argument between wave and corpuscular theories of light, in which the synthesis has to accommodate both models), there is a great tendency for muddle arising from the loose way in which dialecticians speak of contradiction. Criticism, which forms the basis of the antithesis, invariably points out a contradiction. But this can lead to the impression that thesis and antithesis are essentially contradictory, such that any synthesis will have to challenge the law of the exclusion of contradictions of traditional logic. This law asserts that two contradictory statements can never be true together, such that any dialectic synthesis derived from such an argument must be rejected as false on purely logical grounds. But Hegelian dialecticians claimed that this law of traditional logic has been subverted by Dialectic and must be discarded. This action totally destroys the logical argument and renders

admissible and valid any statement whatsoever. We need to step back from this brink.

In purely pragmatic terms the Dialectic can provide a useful classification of the components of a problem once the work has been done. The trade-off then needs to be common to both biology and technology. The speed/accuracy trade-off is relatively simple and ubiquitous and presents good common ground. But how do we translate the biological trade-off of reproduction/ immunity, necessary both to stop the female from rejecting the immunologically alien sperm, pollen, etc., and for the unimpeded development of offspring whose genetic identity will be different from that of the mother? Translation is made possible by an ontology (see Tilting in the Lists over Lists: Database vs. Ontology in ZQ05) based on a Russian method, TRIZ, for solving



This shot of an New Caledonian crow probing into a tube shows how their eyes can swivel forward. Photo: Jolyon Troscianko | www.jolyon.co.uk

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problems in engineering. This method suggests that reproduction is related to "productivity" and immunity is related to an "external source of harm", giving a trade-off that makes sense in an engineering environment. Thus, any trade-off found in biology can be translated into engineering terms.

The trade-off defines a problem, but we still have to solve the problem; in terms of the Dialectic we still need a Synthesis. Biology provides this from the analysis of the trade-off. Unfortunately, even though many biological studies successfully identify a trade-off, less than half of these papers identify the variables that control it. These variables, translated into technology-speak by the ontology, are the agents of change that supply the engineering impulse for biomimetics to work.

I would like to see a biological journal devoted to trade-offs. It would foster the analysis of trade-offs and encourage numerical results, opening up the use of multi-objective analysis and similar numerical techniques that have been developed in technology for the analysis of complex problems. There are very few examples of this approach in biology, but they show that multi-objective analysis is not only possible but can give greater insight into the way variables interact to define and control a trade-off. We are currently trying out the technique on agricultural experiments where the data are complex, with many variables, but reliable and (more or less) complete. With more subtlety of use, the trade-off could become an essential concept not just in biomimetics, but in unravelling adaptation, natural selection and, finally, evolution itself.

Julian Vincent has always been intrigued by the exposed mechanics of insects. Largely in response to broken promises of promotion, he became a semi-professional musician and branched out into areas of science and technology bounded by biology and materials science. Since retiring he has had no laboratory and has had to resort to thinking.

We would appreciate your feedback on this article:





Untitled Photo: Jolyon Troscianko | <u>www.jolyon.co.uk</u>

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Peaceful dove (detail) Leila Jeffreys

Portfolio Leila Jeffreys

AUMAN

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Portfolio

Leila Jeffreys

Fuelled by a fascination with the natural world, Leila Jeffreys sees and senses the lives of birds around her. With each work Jeffreys immerses herself into the birds' world and uses classical portraiture artistry to show the viewer a disparate and entrancing world. Leila Jeffreys launched her sixth solo exhibition *Ornithurae* at Olsen Gruin Gallery, New York in 2017. This followed a succession of major exhibitions featuring her signature large format portraits of birds that includes



Leila Jeffreys

Budgerigars, Cockatoos and Birds of Prey. In Ornithurae, Jeffreys has focused her gaze upon the modest Pigeon, elevating the character and beauty of each individual bird and the species as a whole. Jeffreys has been an exhibiting artist with Olsen Gallery since 2012. Her works are found in private collections nationally and internationally. She has published a major illustrated art book entitled Birdland (launched at the National Portrait Gallery, Canberra) and has exhibited in London, Hong Kong, New York and Sydney. "Through a unique combination of technical skill, ingenuity, patience and empathy, Leila creates objects of art that are luxurious visual pleasures in themselves. By abstracting her subjects from their accustomed context, she demands focus on form, composition and colour. Stark and warm, objective and celebratory at the same time, her photographs not only enhance our personal surroundings by their own decorative presence, but expand our joyous understanding of the world we inhabit, yes customarily see so incompletely in the short time allowed to us." - Dr Sarah Engledow, Historian (National Portrait Gallery, Canberra, Australia)

Could you tell us about this series?

The native doves and pigeon series are images that I desperately wanted to show the world – to give credit where credit is due, so to speak. I assume they are an overlooked species because people associate them with the everyday city pigeon.

Many of us are aware that pigeon homing skills are extraordinary. Scientists testing their navigation have found them to be multi-skilled. This means they are able to return home by evaluating landscape smells, the position of the sun, planetary magnetism, the lines marked by highways, and probably infrasound. Pigeons have returned home after being transported to somewhere new while anaesthetised and sealed inside a metal container on a rotating turntable.

What many are probably not aware is that there are the doves and pigeons of the rainforests that are so beautiful; I would go so far as to call them stunning. The fruitdoves of Papua New Guinea and Australia come dressed as if for a Mardi Gras, in pink, purples, yellows and greens. Arguably, the vivid rainforest fruits they eat have given them an appreciation for colours on each other.

Another reason for celebration is that psychologists take pigeons seriously for

their own reasons, respecting them as birds that excel at visual categorisation. Domestic pigeons in experiments have distinguished letters of the alphabet, different emotions on human faces, paintings by Picasso and Monet, and even breast cancer tumours on scans. In one test, categorising coloured rectangles on a screen, pigeons left university students far behind. Brains wired to detect tiny seeds on gritty ground do well on another kind of flat surface – the screens used in experiments.

In short, they are an incredible species that should be appreciated.

What kind of techniques do you use for your work? And how have you learned to interact with the birds you photograph?

I think the main technique is time. I travel to and meet different birds and if I am able, I will re-visit them and photograph them many times until I capture something I am happy with. This has the advantage of the birds becoming familiar with me and therefore used to me and my equipment.

The best way to interact with them is to understand their body language. They give away a lot and you start to understand how to behave around them to develop a connection.

Portfolio

Leila Jeffreys

How has your art/style changed since you first started?

My bird portraiture work has remained relatively unchanged, in that I use a simple lighting set up and photograph them against a neutral background. What is different is the portraits, as different species of birds have different characteristics and within those species groups individuals can be quite different too.

I print my work 'human size' so that we view them as equals and it's playing with scale that has been a consistent thread with my work.

I have also started to work with video art - that is a change in direction for me but at the same time there is a thread through my work that I hope strongly shows my style of work.

How does photography influence the way you see the world? Do you feel that you see things around you differently?

I don't know if photography influences the way I see the world but more that it is a tool to show the world what I've always observed.

Ever since I was a child I always felt that animals were just as, if not more interesting than people and I understood them better. I saw the world through their eyes and always saw their character and their expressions. Once I had a camera in hand I found a way to reveal that to others.

Who/what inspires you creatively? What do you 'feed' on the most?

I know so many creative people and they are forever inspiring. Michelle Jank is an Australian creative and has become a dear friend. Her talent always inspires me as she is so diverse in what she creates. She once used a reference of one of my cockatoo portraits to design extraordinary costumes of 'creatures' for the London Ballet.

What I feed on the most is bush walks and being in nature, observing wildlife. I live in Sydney, Australia and need to get to wild places often to recharge and inspire me as Sydney is getting very built up.

Can you tell us what you have learned from the birds you interact with?

I have learnt that they are curious creatures, that they can be so smart. They are affectionate and they can also be opportunists. That in a way there are so many similarities. When you break it down to the basics, it's about finding a partner, building a home, having offspring, raising them, resting, playing, and if you're a bower bird, creating beautiful artworks.

I've learnt that the world is a better place because of them for two reasons. The joy they bring to us humans and the vital role they play in keeping our natural environments healthy and alive.

What are you working on right now? Any exciting projects you want to tell us about?

I'm working across so many projects at the moment. I like to create different portrait series on wildlife based around different species groups. But they can be hard to access through wildlife care rescue groups. For example, I've been waiting to photograph an albatross for a seabird series for two years now.

I'm currently looking to work in Iceland to photograph puffins who live in a rescue centre for that same series which I'm very excited about.

What is the last book you enjoyed?

All the light we cannot see by Anthony Doerr. I cried my eyes out. What are your favorite 3 websites, and why?

- Stretch therapy as I get so sore from photography - <u>https://stretchtherapy.</u> <u>net</u>
- Australian Geographic is like National Geographic but specific to Australia www.australiangeographic.com.au
- Birdlife Australia is how I keep up to date with wild birds of Australia - <u>www.</u> birdlife.org.au

What's your favorite motto or quotation?

I've always loved this quote by Ira Glass (US radio personality)

"Nobody tells this to people who are beginners, I wish someone told me. All of us who do creative work, we get into it because we have good taste. But there is this gap. For the first couple years you make stuff, it's just not that good. It's trying to be good, it has potential, but it's not. But your taste, the thing that got you into the game, is still killer. And your taste is why your work disappoints you. A lot of people never get past this phase, they quit. Most people I know who do interesting, creative work went through years of this. We know our work doesn't have this special thing that we want it to have. We all go through this. And

Portfolio

Leila Jeffreys

if you are just starting out or you are still in this phase, you gotta know its normal and the most important thing you can do is do a lot of work. Put yourself on a deadline so that every week you will finish one story. It is only by going through a volume of work that you will close that gap, and your work will be as good as your ambitions. And I took longer to figure out how to do this than anyone I've ever met. It's gonna take awhile. It's normal to take awhile. You've just gotta fight your way through."

For more of Leila Jeffreys' work please visit:

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Nicobar pigeon Leila Jeffreys

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Rose-crowned fruit dove Leila Jeffreys

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Wompoo pigeon Leila Jeffreys



Brown cuckoo dove Leila Jeffreys

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Squatter pigeon Leila Jeffreys



Wonga pigeon Leila Jeffreys


New Guinea ground dove Leila Jeffreys



Kererū Leila Jeffreys



Bleeding-heart dove Leila Jeffreys

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Crested pigeon Leila Jeffreys



Peaceful dove Leila Jeffreys



Topknot pigeon Leila Jeffreys



Superb fruit-dove Leila Jeffreys



Emerald dove Leila Jeffreys

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Common Bronzewing Leila Jeffreys



Young Western Diamondback - Apache Junction, Arizona Photo: Taylor James, 2018

Science of Seeing Learning from No Shoulders Adelheid Fischer

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Learning from No Shoulders

Adelheid Fischer

This past July I found myself nose to nose with a western diamond-backed rattlesnake. This wasn't altogether surprising. Arizona hosts 16 species of rattlers, the greatest diversity of any state in the U.S. The extreme southeastern corner of Arizona, where I live for a portion of the year, is home to nine of them. Venomous snakes—the animals that a friend jokingly refers to as "no shoulders"—are a part of life here. They are especially active during the summer monsoon rains, when adults fan out across the landscape to hunt rodents, lizards, birds and rabbits, and juveniles disperse from their birth sites to begin establishing their own home ranges. In response, residents here change their habits, trading Tevas for closed-toe boots and keeping a flashlight handy on the dashboard to light the way from the car to the house at night.

I've seen my share of rattlers, curled up under rocky overhangs at the side of hiking trails or illuminated in the beam of my headlights as they slide across the roadways on rainy summer nights. But this encounter was different. I had briefly stepped away from my computer at the kitchen table when, through the sliding glass doors, I glimpsed a triangular wedge of head peering over the concrete slab of my back porch. Like the periscope of a submarine, it slowly swiveled left and then right, as if to make sure that the coast was clear before sidling up on my porch to leisurely inspect the premises. In the four years I've lived here, I never had a rattlesnake get this close to the house so I got down on the floor to get a better view. After all, how often do you get a chance to safely stare into the eyes of a wild diamond-back at a distance of a few inches?

Seemingly unaware of me, the snake went about business as usual, flicking and tasting the air with a forked tongue that resembled a ribbon of glossy black licorice. I admired how the latte-colored diamond pattern on the back of the snake took on an almost coppery sheen near its belly and wondered if it had just recently shed its old skin. At one point, I laughed out loud when the snake reared after its nose hit the sticky mesh of a spider web, much like the instinctive recoil of a human after wandering into a web in the corner of the basement. But when the rattler began to climb the screen, things got a little too close for comfort. I quickly closed the door and decided to observe it through the glass instead. Moving with what looked like hundreds of tiny independent muscles, it hoisted more than half its body length up the vertical face of the door before collapsing into a soft heap. Undeterred, it attempted the maneuver again and again until it finally gave up and slid off the porch and down the driveway.

Deformed Western Diamondback - Four Peaks Wilderness Photo: Taylor James, 2018

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Young Western Diamondback - Apache Junction, Arizona | Photo: Taylor James, 2018

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Truth be told, even though I knew there was a solid glass barrier between us, I felt a little queasy in the knees. I had read about the horrendous aftermath of snakebites, how the venom can dissolve muscle and blood vessels into a painful mass of swollen black tissue, or worse, disrupt the communication of neurotransmitters, leaving some victims clinging to life on a ventilator. I had slowly climbed a ladder of terror and was having some difficulty talking myself down.

When it comes to rattlesnakes, however, the danger must be put into perspective. Millions of people hike, bike, camp or four wheel the Arizona back country each year. On average, there are only about 150 reports of venomous snakebites. Most of them are what experts call "illegitimate." Nationwide, the vast majority of snakebites - some 75 percent of them—happen to "people who knew that they were dealing with a rattlesnake but just kept poking it or picking it up or bothering it repeatedly," explained Dr. Erika Nowak in a 2002 New York Times article. People like Victor Pratt of Coolidge, Arizona. In 2017 a rattlesnake wandered into the backyard birthday party for his child. Pratt decided to entertain friends and family by lying on the ground and pretending to wrestle the snake before killing it and throwing it on the barbecue. But when he lost control, the snake struck him in

the chest and face. Pratt was rushed to a nearby hospital just as the swelling in his neck began to close his airway. He was later airlifted to a hospital in Phoenix where he spent five days heavily sedated on a respirator. Pratt was an extreme case, and yet even he survived—as do most people who have been bitten by rattlesnakes. Compare that to the nearly 1,000 people who died in car crashes in the state in 2017.

Yet the fear of snakes often runs so deep that people cannot bear to even look at a photo of one on a page much less observe it slithering around in the wild. Lynne Isbell, a University of California, Davis, anthropologist, has tendered a controversial explanation for this deep uneasiness. In laboratory tests, she and her colleagues have shown that neurons in a part of the brain's visual system, known as the pulvinar, are exquisitely sensitive to snake images. The pulvinar, which is unique to primates, including humans, monkeys and apes, serves as a kind of early warning system. Throughout 60 million years of evolutionary history, she says, primates became so visually tuned to the danger of venomous snakes that they glimpsed them and physically reacted to them long before their conscious minds had a chance to fully register their presence. The upside, she suggests, is that the need for early detection

Mountain Phase Black-tailed - Superstition Mountains Photo: Taylor James, 2018

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Young Western Diamondback - Apache Junction, Arizona | Photo: Taylor James, 2018

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of dangerous snakes over long evolutionary time may have driven the refinement of their visual capacities such as depth perception and color vision. As potential evidence, Isbell points to the lemurs of Madagascar, who evolved in habitats devoid of venomous snakes. Unlike their primate cousins in snakier parts of the world, lemurs have notoriously poor vision. By and large, humans and their close relatives "have very good visual acuity, the best in the mammalian world," Isbell says. "So there has to be some sort of explanation for it."

These days, though, it's hard to know whether humans or vipers have more to fear. In places like the deserts of the American Southwest, the numbers of some rattlesnake species are dwindling. Like many desert plants and animals, they suffer from encroachment on or destruction of their habitats. Poaching by reptile collectors is contributing to the toll. But rattlesnakes also succumb to a human pressure that is reserved for few other animals: a mindless persecution that is fueled by outright hatred. Of the nine species of rattlesnakes in southeastern Arizona, four have been given protected status.

It's clear that we need to recalibrate the grave mismatch between our ancient fears and contemporary realities. Yet what can help move the needle from a primal terror of snakes to the respect and admiration they deserve?

One of the most powerful, persuasive tools is scientific research. Until recently, reptiles such as rattlesnakes have been extremely difficult to study in the wild largely because they spend a good part of the year underground. During their active seasons, these ambush predators remain cryptically coiled for long periods of time under rocks and bushes waiting to nab an unwary rabbit or desert rat. For a long time, scientists were privy to only the scantiest information about the daily life of snakes in the wild. But technology has given us a window into the fossorial habits of rattlesnakes, thanks to radio-telemetry, which began to be used to study reptiles in the field in the 1980s, and other technologies such as wildlife cameras, global positioning system (GPS), DNA fingerprinting and embedded microchips that allow animals to be identified through easy-to-scan barcodes.

What we've learned has stumped and astounded even the most senior rattlesnake researchers. New information about vipers is not only upending many of our fundamental assumptions about them, but this knowledge also is opening up potential new human applications. Engineers, for example, are studying the distinctive locomotion of sidewinder rattlesnakes in order to create robots that can more effectively negotiate unstable surfaces such as the slip-slidey slopes of sand dunes. Even the fearsome rattlesnake venom is sparking new medical possibilities. Biochemists, for example, have discovered that cancer cells are more susceptible to the potent proteins in snake venom than healthy cells and are exploring ways in which they might mimic these anticancer properties in new treatments.

These days, it seems that mind-bending headlines about the ordinary lives of rattlesnakes appear with about as much regularity as the change of seasons. Over the next year, I plan to explore some of them in this column. In the meantime, here is one story that has helped reroute my own journey from fear to fandom.

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June is the hottest and driest month in Arizona. I am reminded of this climatic rule of thumb as I step out of the car on an early June morning in 2017 and instinctively head for the nearest shade tree in Barney Tomberlin's yard. Tomberlin is a well-known snake catcher in the tiny town of Portal about 60 miles north of the Arizona-Mexico border. If residents find themselves with a venomous snake that has settled in for one too many siestas under their favorite porch chair or has claimed squatter's rights in one of the dark corners of the horse barn, Tomberlin will show up with snake tongs and a bucket and gently relocate the animal to a less-contested part of its territory.

The point of my visit here this morning, however, is not to report a truant snake. I am here to meet Gordon Schuett who. like Tomberlin, is a member of the local herpetological community. Schuett, now fifty-something, began visiting this part of the world in 1975 when he was barely out of high school. He was drawn by the region's extraordinary rattlesnake diversity and even as a teenager vowed someday to move here permanently. In 2018, after teaching stints at Arizona State University and jobs as a zoo reptile curator, Schuett relocated to the bootheel of New Mexico, some five miles across the state line from Portal, and began living his dream.

Schuett has studied rattlesnakes for decades and his knowledge is encyclopedic, much of it gained from thousands of hours of observations in the field and in the lab. And no question is too trivial or too lame. As a result, he has participated in a dizzying array of projects. He and his collaborators have published papers ranging from parthenogenesis in snakes (the ability of females to give birth to offspring without the donation of sperm from males) and long-term storage of sperm in female diamond-backs

Desert Phase Black-tailed - Table Top Wilderness, Arizona | Photo: Taylor James, 2018

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CHERRY MAN

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(up to five years!) to prey-luring behaviors among baby sidewinders. One of my favorites is a 2018 mind-bender detailing the startling discovery that rattlesnakes are a major disperser of seeds in the desert. Researchers have long known, for example, that kangaroo rats are a prey staple of rattlesnakes. These rodents (which are not true rats but belong to a group known as heteromyids) store the seeds they have collected in exterior cheek pouches. As the animals move through the snake's lower gut, primarily the colon, the seeds they carry are not broken down but begin to germinate. When the animal defecates, the seeds. which have been given a head start in the bowels of the snake, also receive a dollop of fertilizer to help them get established in the landscape. "These snakes," Schuett points out, "are more than mere automatons slithering in the wilderness."

Today, however, Schuett is keen to discuss a startling behavior in diamondbacks that he first witnessed in 2006 in a group of wild snakes north of Tucson. To demonstrate, Schuett grabs a water hose and we walk to an outdoor pen where Tomberlin keeps several captive snakes. I peer through the wire into the jumble of rocks and plywood hoping to catch sight of one of them coiled in the debris. The pen appears to be empty. Then Schuett points the hose up into the air and turns on the spigot. A high arc of water falls like a soft rain into the cage. The air quickly fills with the sweet scent of water. Within seconds. the telltale chicka-chicka-chicka sound of a rattle can be heard as one, two, then three rattlesnakes slide into view. Before long, 12 snakes emerge, their rattles sounding off like a group of loopy musicians playing castanets at an ad-hoc street party. Then the animals do something strange and remarkable. They flatten their bodies and form a tight coil. After a few minutes of wetting, the head of each snake reaches around and begins actively probing the coils, appearing to nuzzle its own skin using rhythmic jaw movements. Schuett points out that the snakes are using suction action (and not their nimble tongues) to imbibe the water captured in their coils. As the snakes drink, they make minute, almost rippling adjustments with their bodies.

It's called water harvesting. The term was coined by Wade Sherbrooke, another biologist who has worked in the Portal area, to describe how the horned lizards in the desert here modify their stance—flattening their bodies, splaying their legs and lowering their heads and tails—to increase the surface area for collecting precipitation during storms. Water streams into the channels between the lizards' scales and is then conveyed to their mouths via capillary action. In a rainstorm, the body of the lizard becomes a miniature watershed of many tiny creeks all flowing into the animal's throat.

When it comes to water, rattlesnakes face similar challenges as horned lizards. Although they obtain vital fluids from the prey they consume (known as metabolic water), they nonetheless rely on supplemental infusions of drinking water. But crawling around in search of extra moisture in a place where permanent water is rare and standing pools often evaporate only hours after filling can be a death sentence. The ability to snag water on the spot whenever it rains is a brilliant solution in a place like the desert where precipitation is sparse and unpredictable.

And like horned lizards, rattlesnakes use what comes most readily to hand: their own bodies. Documented cases of water harvesting in rattlesnakes goes back to 1927. These observations, however, were recorded in the summer months when snakes were active on the surface. Once cold weather set in and the reptiles retreated to winter shelters to hibernate, researchers simply assumed that they were unable to take advantage of winter rainfall. Not so, Schuett discovered. Nearly every weekend for 16 years, he and colleague Roger Repp had been visiting six

communal dens in the Sonoran Desert north of Tucson, Arizona, where diamond-backs congregated to spend the winter. In March 2006, the pair set out into a blustery latewinter storm that broke a 175-day streak without rain, bringing lashing winds and heavy rains that occasionally turned to sleet. The thermometer hovered around 40 degrees F. As they approached the dens, Schuett and Repp expected to find the snakes safely tucked away. Snakes rely on the warmth of their environments to raise their body temperatures. In cool weather, they are sluggish and slow, vulnerable to predation from badgers, bobcats, hawks and other animals. Yet, much to their amazement, they witnessed the animals venturing out into the open. Some of the snakes formed coils that captured rainwater or melted sleet into a drinkable liquid. Others sipped from small pockets of accumulated water, flowing rivulets or trickles of water that streamed down nearby rocks. The discovery was a scientific first.

This natural history nugget could easily have remained little more than an interesting tidbit of information to be passed around at a cocktail party of herpetologists. But Schuett was determined to know more so he examined a sample of rattlesnake skin under the microscope. Snakeskin is composed of hundreds of tiny scales. Some

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snakes have smooth scales. Others, such as rattlesnakes, have a small ridge, or keel, running through the center of each scale. Those with smooth scales do not engage in water harvesting. On the other hand, nearly all snakes that drink water from their own bodies have keels. Furthermore, Schuett noticed that the animals appeared to have precise control over the movement of these scales during water harvesting. What was the purpose of these keels? he wondered. Could they serve as a kind of hydrophobic divider that helps direct rainwater into the surrounding interstitial tissue where it can be suctioned up by the snake? Could the scales shape-shift to direct the flow of water and maximize water capture?

We may soon know the answer to these and other questions. With the support of a grant from the Biomimicry Center at Arizona State University, Schuett has teamed up with ASU engineering faculty Konrad Rykaczewski to better understand the physiology of snake skin as well as its structural and material properties. Preliminary investigations may be upending some of the researchers' original hypotheses. Much to their surprise, in laboratory tests the keels appear to attract and hold droplets, serving as a kind of water-capturing rather



Snakes that engage in water harvesting have keels that run through the center of their scales, such as this one from a western diamond-backed rattlesnake. Photo courtesy of Konrad Rykaczewski and Gordon Schuett, 2018 than water-dispersing feature. Like the Namib beetle, whose hydrophobic and hydrophilic cuticle has inspired technologies for condensing water from atmospheric moisture, snake scales may offer another useful approach to accomplishing the same critical task. In addition, their shape-shifting properties could give rise to new kinds of material surfaces that respond to and flex with changing conditions, making them valuable in applications such as more efficient ways to generate energy or cool microelectronics.

In the meantime, Schuett is continuing to ask fundamental questions about the animals he has come to admire and love. Next on the list of inquiries is their excrement, in particular, the urine of boas and pythons. Schuett relays the experience of a colleague who keeps an 18-foot reticulated python in captivity. Cleaning its cage is a job for a champion weightlifter. "When the excreted urates, which both look and feel like toothpaste, make contact with the floor of the cage," Schuett says, "over a period of several days the mass dries, hardens and becomes firmly attached so much so that you need a hammer and chisel to remove it. We don't know why the urates of these animals need to be able to stick to objects with the strength of superglue. Perhaps in the wild it becomes a way to

signal a territory. But there is something more in their waste products than just uric acid, some kind of natural polymer that is acting in an amazing way like concrete. This and other similar phenomena are poorly understood in snakes. Unfortunately, there probably isn't adequate funding to explore this."

But that is changing, thanks to researchers such as Schuett. He spends countless hours looking at nature and asks fundamental questions about seemingly ordinary phenomenon, revealing the astounding goings-on at the heart of the everyday. "The natural world is an amazing playground of stuff," he says. "I am always out in the field observing. I'm like a kid in a candy store. How many people have watched geckos climb walls for millennia? Who would have known that observations of geckos would lead to amazing discoveries in nanotechnology? There are dozens of observations like that that people could make careers out of."

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Book review Bioinspiration in Business and Management by Dr. Taryn Mead Reviewed by Dr. Daniel Weihs, Karen Verbeek, and Norbert Hoeller

Bioinspiration in Business and Management by Dr. Taryn Mead Reviewed by Dr. Daniel Weihs, Karen Verbeek, and Norbert Hoeller

Bioinspiration in Business and Management by Dr. Taryn Mead explores "business inspired by nature", targeting managers and sustainability professionals at multiple levels within their organizations. It looks at the applicability of bioinspiration not just within the realm of technology products, but also organizational and "systemsbuilding" innovation that extend beyond the individual organization to include socioecological systems. Mead takes an inclusive approach that covers the breadth of "learning from nature", reaching out to readers motivated by sustainability, a fascination with nature, or innovation itself.

Bioinspiration can be defined, described and applied in very different ways. Mead chose Innovation for Sustainability as the theme and subtitle of the book. As an introduction for busy people in management and business who are not directly involved in bioinspiration, the author had to compromise between breadth and detail. This short book, which is more like a position paper and review of the field, can give the busy manager enough insight and examples to engage both research division staff and entrepreneurs. The content provides enough material for the reader to understand bioinspired proposals and assess their value.

A few words of caution are needed. Mead's basic "premise is that all of the

organisms living on the planet know how to be sustainable" is not universally true as most animal and plant species as well as specific functions are extinct, many of them due to overuse of resources. Also. when looking at nature for inspiration, one needs to remember that each organ and unit must respond to many different inputs, mostly not relevant to human requirements. Assuming that nature provides optimal solutions is dangerous as these are usually suboptimal compromises with limitations that may not be relevant in the technological implementation. The best example is flight, where biological limitations precluded the use of rotating shafts leading to early attempts at flapping flight – and Daedalus.

The book begins with an overview of the breadth of bioinspiration from our earliest attempts to understand and apply principles from nature, through Leonardo da Vinci's detailed observations and applications of organisms and organs, and to modern examples. Mead describes the context of bioinspiration within the relatively recent (in historical terms) emphasis on mechanistic/reductionist models that separate humans from nature. Although these anthropocentric worldviews have proven to be very useful, they limit our ability to think effectively about complex systems that require a more ecocentric perspective. The author proposes a similar paradigm shift is occurring in the business world, providing a timely opportunity for bioinspiration.

Mead defines bioinspiration as "innovation and design inspired by nature with an intention of enabling humans to become a better-adapted species for life on earth." The business implications are explored through three models: disparate, intertwined (often associated with the Triple Bottom Line), and embedded (where business is nested within society and nature). The author then discusses the terms sustainability/resilience/regeneration and describes various perspectives relating bioinspiration to sustainability while pointing out that not all solutions based on nature are sustainable.

Mead positions bioinspiration at three levels within organizations.

• "Innovations in Management" discusses how bioinspired metaphors can



Guineafowl Butterfly (Hamanumida daedalus) Photo: Bernard Dupont, 2015 | Flickr cc

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influence management approaches and organizational structures, highlighting how Interface and Ecover have adopted bioinspiration as a core concept for sustainability. Other examples include swarm theory at Southwest Airlines, the management structure at WL Gore and Associates, high performance team principles, chaordic organizations, and lessons from ecosystems. Mead points out that some of the attributions to bioinspiration remain to be verified, and metaphors are sometimes misused.

- "Innovations in Operations" promises to explore analogies from nature that can be applied to business operations, including Industrial Ecology/Symbiosis (Kalundborg, Cardboard-to-Caviar), Life Cycle Analysis, The Living Building Challenge, and Ecological Performance Standards.
- "Innovations in Product Development" covers tangible bioinspiration examples including the Shinkansen bullet train, biomimetic optimization methods, the Vitalis water bottle (lighter weight, but still disposable), PureBond wood products, ways to sequester carbon, additive manufacturing, "closed loop" designs, and regenerative innovation, such as the Interface Net-Works initiative.

"Bioinspiration in the Global Context" looks at the larger systems in which businesses operate, exploring resilience through diversity, connectivity, feedback loops, and understanding "slow variables" that can suddenly shift state. Mead explains how the interplay and balance of these characteristics enable natural systems to survive in contrast with the traditional view of efficiency and redundancy in organizations. Mead provides a nuanced exploration of cooperation and competition, noting that we tend to see competition in nature relating to food and procreation. This chapter describes the Circular Economy concept that has gained considerable business traction in a short period of time. "Process and Conceptual Tools" lists a wide range of tools for different aspects of bioinspiration.

"Thinking Strategically" identifies three organizational cultures centered around their narratives relating to sustainability and innovation. Ambiguous organizations have the weakest sustainability leadership and struggle to implement bioinspiration within their innovation processes. Accountable organizations have strong sustainability cultures and processes, but these may limit their ability to gain the full benefit from bioinspiration. Aspirational organizations are likely to use bioinspiration for expansive and radical innovation. As



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Mead points out, the organizational culture is very important in understanding how, where and why R&D investment in bioinspired innovation can benefit the project and the organization in the longer term. To reap the problem-solving benefits of bioinspired design, Mead recommends it be used for radical transformation rather than incremental change.

Discussion

Mead points out that the relationship of bioinspiration to sustainability remains hard to pin down, particularly when we take what we have learned from nature out of context. Many practitioners in the broader field of bioinspiration have raised concerns about tying bioinspiration to sustainability, due to the limited evidence and the concerns that it limits the potential client base. Mead's suggestion that using bioinspired innovation strategies to create culture rather than products points to a potential solution. Evaluating organizational culture provides insight and strategies to improve the implementation of bioinspired design.

Metaphors can help us break free of well-worn ways of thinking but may not help us deliver tangible results. Metaphors are 'context free', which is attractive, but context is important when bridging the gap between biology and engineering. Metaphors can be used for 'after the fact' attribution of bioinspiration. Relying on metaphors can also inhibit us from 'digging deeper' - "waste is food" does not help us understand how nature solves the inherent contradiction. Much of this book relies on metaphors, even Chapter 4 on "Innovations in Operations". Moving away for metaphors, Nieuwenhuis and Lammgård (2010) explored how the Industrial Ecology narrative could be extended, while Layton et al. (2015) demonstrated that Industrial Ecology could benefit from current research in ecological food webs.

Mead provides tips for implementing bioinspired design by using a combination of leadership, process, tools, skills and mindset. Except for the biomimicry tools and methods, many of the tools described in Chapter 7 are not designed specifically for bioinspiration. Although they can be useful to bioinspiration practitioners, they do not address the unique challenges that practitioners of bioinspiration face. The list of tools developed by Wanieck et al. (2017) contains a higher proportion of bioinspiration-specific tools. More research is required to assess the value of these tools in business practice, including their applicability, maturity, and support structure - are they "useful, usable, used" (attributed to

Appleton, 1998)? How can these tools be combined and integrated with innovation methods common in business, such as Design Thinking?

Many businesses believe that they must compete to survive, particularly in today's fast-changing, global economy. Can bioinspiration help businesses understand how their success depends on social and ecological systems? As an example, businesses can use Ecological Network Analysis (https:// issuu.com/eggermont/docs/zqissue17/28) to map the complexity of their flow networks, develop relevant metrics, identify opportunities for improvement based on ecological research, and model the interventions to reduce risk. In the process, businesses can begin to see how their flow networks are linked to socio-ecological systems, helping them move along the continuum of the three sustainability cultures described in chapter eight.

Business acceptance of bioinspiration has yet to match the more recent adoption of Circular Economy concepts. The book did not explore what bioinspiration could learn from the success of the Circular Economy concept. What caught the attention of the MacArthur Foundation (https://www. ellenmacarthurfoundation.org/)? How was the McKinsey & Company report funded (https://www.ellenmacarthurfoundation. org/news/towards-the-circular-economy)? How was the concept communicated in ways that attracted the interest of business but more importantly, encouraged and enabled businesses to implement the concepts?

Bioinspiration can be an extraordinarily successful tool for innovation and it is important that business leaders include it in their considerations. This book can have a useful role in achieving such understanding, and Mead is to be congratulated on the initiative.



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Professor Daniel Weihs (PhD Technion, 1971) is Head of Technion's Autonomous Systems and Robotics Program. At Technion, he was previously Provost, Dean of Aerospace Engineering, Dean of the Graduate School, and Head of the Neaman Institute for Advanced Studies. He was also Chief Scientist, Israel Ministry of Science. He is presently the Chairman of the Interuniversity Marine Science Institute, Eilat Israel, and an Advisory Board member of the Global Drucker Management Forum. He has published over 170 archival papers, two books (one in Korean), given over 130 invited lectures, has several patents, and one postage stamp.

Karen Verbeek's interest in bioinspiration brought her to the Biomimicry Workshop in Costa Rica in 2009. Previously, she worked in the plastics, contract furniture and toy industries. She obtained her BSc in Biology, followed by a BID (Bachelor of Industrial Design), and later obtained a Green Business Management Certificate. Originally, having an industrial design/ product development perspective, Karen is now interested in the large impact its use in systems, management and organizational opportunities could have on a sustainable future.

We would appreciate your feedback on this article:


Monarch Butterfly Chrysalis Photo: unknown, 2006 | Wikimedia Commons

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A proposal for a future blue-green Orleans Basin between Lake Pontchartrain and the Mississippi River. Source: Greater New Orleans Urban Water Plan

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David Waggonner

David Waggonner is the founding principal of Waggonner and Ball Architecture/ Environment (https://wbae.com/), an award-winning, internationally active architecture and planning practice located in New Orleans. The firm's architectural work varies from historic preservation to modern institutional projects. In the aftermath of Hurricane Katrina, David saw an opportunity for New Orleans to reinvent itself as a sustainable city that embraces its lifeblood, water. He championed a process that examines history, soils, biodiversity, infrastructure networks, and urban space, along with the forces of water. This combination serves as a holistic foundation for design. first developed during the Dutch Dialogues and continuing through the Greater New Orleans Urban Water Plan.



David Waggonner

What is the "Living with Water" project?

Greater New Orleans is defined by its relationship to water, and the abundance of water in this region. The Mississippi, Lake Pontchartrain, cypress swamps, and winding bayous once defined our landscape. Today the water is almost invisible and rarely accessible. Levees, floodwalls and buried culverts keep it out of sight and out of mind.

"Living with Water" is not only about flood protection and canal beautification. It's a fundamental change in the way we think about water every day. It's a movement to recognize the beauty and realize the benefits inherent in our landscape. Water can become our greatest asset. A safe, attractive future is not so hard to imagine if you see what's right behind the floodwalls.

In addition to projects in New Orleans, "Living with Water" has inspired projects in Norfolk (Virginia), Bridgeport (Connecticut), and Isle de Jean Charles (Louisiana).

What are the challenges in New Orleans?

New Orleans has largely recovered from Hurricane Katrina, but it needs to deal with near-tropical rainfall almost every year. It suffered severe flooding last August due to heavy rains that caused major power outages. The New Orleans drainage and

Flying into NOLA (Louisiana, on approach to New Orleans) | Photo: pinelife, 2016 | Flickr cc

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The Greater New Orleans Water Plan is a comprehensive vision based on water, the region's most fundamental asset. Source: Greater New Orleans Urban Water Plan

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David Waggonner

pumping system is designed to take the water away after the rain, but the pumps failed. People at the Sewerage & Water Board lost their jobs.

The Water Board's focus has been on a drainage master plan, using levees and pumps to keep the water out and allow development of land lying below sea level. However, constantly pumping water out causes subsidence, further exacerbating flooding. Diverting the Mississippi and preventing it from nourishing the delta has increased the impact of sea level rise and storm surges.

New Orleans is a large city but has lost 20% of its population and struggles to pay for the current flood control infrastructure, much less infrastructure improvements. There is a growing interest in exploring natural solutions, but we struggle to connect all the elements. Each group has its own interests, which is exacerbated by the fragmented parish political system. well as its culture. The water crisis creates opportunities for investment in natural systems that support what makes New Orleans unique, delivering economic growth and reducing inequity, while ensuring safety and managing risk.

New Orleans has introduced stormwater regulations that provide incentives to manage the problem locally and encourage creative thinking. A new contractor in New Orleans is setting up a green infrastructure construction division that builds the next generation of streets with bioswales and the other elements now required by the stormwater ordinance.

As a part of National Disaster Resilience competition that funded both design and build, we are involved in design and construction pilots in the Gentilly Resilience District of New Orleans, Norfolk, Bridgeport, Isle de Jean Charles, and for the State of Louisiana. These pilots are experiments that may be going against the tide, but the tide will sweep us away unless we do something different.

| What progress are you seeing in New Orleans? | |
|---|---|
| To deal with the infrastructure issues and flooding we need economic growth New | How is the situation different for the other projects you are developing? |
| Orleans attracts tourism because of the | Rising sea levels and flooding are also |
| beauty of its landscape and buildings as | affecting places such as Norfolk (Virginia), |

1.4.41

with the world's largest naval base, and Bridgeport (Connecticut) where we are dealing with regional utilities in the middle of a relatively poor community. Although the underlying causes are the same, each situation has a different context, players, and dynamics.

Norfolk recognises that it has no choice. Langley Airforce Base is only a few feet above sea level. The ships at Naval Station Norfolk can float, but the sailors may not be able to get to them.

What is slowing progress to resolving these issues?

America is being pulled apart by a wide range of forces. We struggle to deal with complexity – we try to reduce it to parts that appear to be solvable but only in isolation. People are reverting to their own comfort zone of reduced realities. A Public Works person said I could build all the bioswales and green infrastructure I wanted, but he would not maintain them because his his world is about drainage and pumping systems. We revert to reacting to the last problem, rather than addressing the higherlevel underlying problems.

Beyond convincing people to try a new approach, we need to figure out the design

and implementation challenges. When markets are immature, the signals are weak - the supply chain often does not exist. Long term funding strategies are needed to support development of the necessary design/build expertise.

New approaches mean new construction and maintenance costs, which are often treated as an addition to existing costs. More than 80% of the cost of the New Orleans pumping system is in operations and maintenance. The challenge is figuring out the offsets created when we implement natural stormwater management. There is also a tendency to only include narrow benefits that do not consider the broader community value of green/blue infrastructure.

How did we get to the point where nature is about individual contemplation, rather than the community? How do we develop a narrative that better communicates the truth? How can we capitalise on the values of nature and capture all the benefits of these approaches? How can local initiatives be tied together into a larger network? We tend to talk with people of like minds, instead of reaching out to the broader audience. We need to help everyone understand how they would benefit from change.

David Waggonner

Circa 1718 Founding on the Riverbank



Circa 2000 City Between River and Lake



New Orleans' 20th century denial of water caused the city to sink as wetlands were developed into suburban housing. Source: Greater New Orleans Urban Water Plan

Recognizing the strategic location at the mouth of the Mississippi, Bienville founded New Orleans on the riverbank.



Settling of the soils below sea level and the loss of wetland buffers increase vulnerability to hurricanes, and damages to infrastructure



David Waggonner



The Mirabeau Water Garden highlights a new infrastructure investment model that provides multiple community benefits while storing and treating stormwater. Source: Greater New Orleans Urban Water Plan



Is there room for optimism?

Our problems are often of our own making – the simplest systems are natural systems that have evolved to deal with complexity. The common-sense agenda is working with nature rather than controlling and fighting nature.

There are opportunities to create much better living conditions and to start and grow new businesses and industries. Most importantly, there are opportunities for people to think more holistically about their impact on the environment, and their environment's impact on them. Focusing on the natural aspects of green/blue infrastructure can help establish a common ground and build working relationships across silos. The challenge is communicating effectively and identifying short-term actions that have long-term positive impacts.

New Orleans can create a water-based economy that can benefit everyone, regardless of income levels. Rather than fearing water, we have can re-integrate water management as a positive element of our urban environment. We have an opportunity to building infrastructure that serves multiple purposes, that is a community investment where we all get our money back.

David Waggonner

What are other areas and countries doing?

The Pacific North West has the advantage of living in a healthy condition closer to nature, which supports a different mindset than the 'drainage' model of New Orleans. China is investing heavily in its 'Sponge City' concept – it has been rapidly building infrastructure that stores and absorbs water back into the ground, although not always in a way that supports long-term maintenance.

The Dutch have been dealing with water for centuries. They have made a lot of mistakes but are constantly evaluating whether an approach is an investment for the long term, rather than focusing on what they can afford to spend now. The economy and industry have responded so that the Dutch can build this kind of infrastructure much more affordably than we can. According to the Dutch, they get a four-fold benefit from green infrastructure.

What key messages do you have for our readers?

- Accept nature on its own terms, rather than a sanitized and controlled version of nature.
- Focus on the local, then think about the regional, nation, and global implications.





Water is the foundation and plays a role in all aspects of urban land use, from parks to transportation and ecological corridors through the city. Source: Greater New Orleans Urban Water Plan

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The retrofit and adaptation of existing infrastructure, like New Orleans outfall canals, will be critical for building resilience in established cities. Source: Greater New Orleans Urban Water Plan

- Make the narrative desirable to a broad audience.
- Deliver a broadly accessible return on investment.
- Combine a bottoms-up movement with higher-level initiatives to reduce fragmentation and polarization.
- Incorporate lifecycle assessment of the direct and ancillary costs/benefits.
- Strengthen feedback loops so that issues can be identified earlier rather than pushing off decisions to the future.

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Resources

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