

# Biomimicry and the life-friendly economy

MechChem Africa talks Claire Janisch, head of biomimicrySA. Janisch promotes the practice of biomimicry in business strategy, technology and education. She was also a co-creator of the Genius Lab, an experiential learning organisation that inspires innovation and future thinking.

“I studied chemical engineering and completed a Masters in Environmental Process Engineering, with the idea of improving mainstream processing to reduce environmental impacts. For ten years following my graduation, I worked in environmental engineering with a focus on some of the most hazardous industries: mining, minerals processing, metal plating, cement and agricultural fertilisers.

“The purpose of these processes is to generate functional materials and services to improve standard of living, yet many of them use toxic materials in their processes and vast amounts of water and energy. A great deal of waste is generated, which has to be cleaned up to prevent danger to people and the environment. Is it not possible to meet our functional needs without generating such a mess?” she asks.

“When I was introduced to biomimicry I realised that it is. We can make almost everything in chemical engineering in ways that are nourishing to life. Almost every functional material or process has a counterpart in nature that uses life-friendly materials, low energy processes and continuously cycles all the materials used, including water and carbon,” Janisch informs *MechChem Africa*.

She cites a 2014 article in *Forbes* magazine that identified the top five trends driving company success. Biomimicry was Number 1,

with additive manufacturing (AM); software, big data and the Internet of Things completing the list. “While everyone knows that 2 to 5 are exponential technologies driving the 4<sup>th</sup> Industrial Revolution, where does biomimicry fit in?” she asks.

Claire Janisch argues that, in fact, all these exponential trends are rooted in biomimicry. Robots mimic the hands and limbs of living species; drones are only just getting close to achieving the flight and vision capabilities of nature’s dragonflies; neural networks strive to copy how the brain remembers, makes links and learns; digital intelligence connects individuals in distributed networks similarly to the swarm intelligence of nature’s social species; and the IoT echoes the central nervous system, using smart sensors that are nowhere near as finely tuned as those used by insects and animals.

“Think about data storage. We know that a few grams of DNA can store a billion terabytes of data. And with respect to sustainable energy, nature has been running on sunlight for millions of years. 3D printing is also nothing new. Every one of us was created cell by cell, layer by layer, as was every living organism,” Janisch points out.

“I liken the solutions found in the natural world to running a four minute mile. Once we knew it was possible, many started to do so. Similarly, now that we know it’s possible



to meet our functional needs in life-friendly ways at very low temperatures, it’s a matter of time before we are able to reverse engineer these options and create highly functional industrial materials that are non-toxic, use low-energy and cycle water and materials in regenerative loops.

“Many of the recipes, processes and systems strategies are there, hidden in plain sight, just waiting for us to recognise their potential and put some effort into reverse engineering a biomimicry solution,” she argues.

“The potential is huge. And we are in a better position than ever before to take advantage. 3D printing and nanotechnology make it possible to more accurately mimic the way a spider weaves its web, for example, by depositing layer upon layer of protein hydrogels that quickly set into silk as the water dries off.

“Not only can we now mimic these processes, but with advanced equipment such as electron microscopes, we can also study how nature works in much finer detail. We can see and make sense of the vast number of functions taking place on the nano-scale. Better research capacity makes it easier to recognise and understand nature’s processes, while technologies such as nanotechnology, 3D printing and advanced computing make it possible to mimic nature to develop benign materials and low-energy manufacturing processes,” she explains.

The use of biomimicry in engineering is not new. One need only look at early designs of flying machines to see that early inventors such as Leonardo da Vinci were mimicking nature. But they were limited by the available materials and technology of the day.

“From a modern design perspective, the limits are now significantly extended and we believe biomimicry should be the first thing engineers turn to when striving to improve or develop a new material, product, system or industrial process,” she tells *MechChem Africa*.

## The circular economy and ecosystems

Human engineering has long claimed to be able to make products and processes more efficiently than nature. The pursuit of higher and higher efficiency solar panels is one example. To make these panels, however, toxic chemicals and large amounts of energy are needed – emitting large amounts of CO<sub>2</sub> during manufacture – and after use they end up in land-fill.

A leaf, on the other hand, uses the energy of the sun to 3D-print a life-friendly polymer at low temperatures with carbon as a raw material, all while cycling carbon, breathing out oxygen and driving the rain cycle. And when it’s life is over it ends up as compost, feeding the soil. Nature’s advanced technologies such as these are continuously creating conditions conducive to life.

At a systems level, this is far more efficient than humans achieving high-efficiency for a single component such as a solar panel, while ignoring expensive externalities across the product’s life-cycle, such as raw material extraction, manufacture, use and disposal.

According to a report by environmental consultancy Trucost on behalf of The Economics of Ecosystems and Biodiversity (TEEB) programme sponsored by the United Nations Environmental Program, “none of the world’s top industries would be profitable if they paid for the natural capital they use.” These unpriced natural capital costs include greenhouse gas emissions (38%); water use (25%); land use (24%); air pollution (7%); land and water pollution (5%), and waste (1%).

The report found that the total unpriced natural capital consumed by the more than 1 000 global primary production and processing industries amounted to US\$7.3-trillion per year, equivalent to 13% of global GDP in 2009.

“In comparison, naturally evolved processes integrate all these externalities, yielding systems-level efficiencies,” says Janisch.

Ecosystems such as forests, grasslands and coral reefs, continue to grow and develop over centuries, cycling all materials and contributing to the conditions that ensure the system and life thrive – building soil, cleaning water and generating a safe cocktail of gases that supports life.

Nothing is cast out of a forest as waste and even urine and faeces are recycled for use as food and fertiliser. Sunshine and water collection are optimised in each context and the interactions between all species have evolved and adapted over thousands of years to be resilient and regenerative. These environments are the ideal of a circular economy.

“Using biomimicry as model, measure and mentor, it is possible to emulate nature’s ecosystems in many ways, which is why biomimicry and the circular economy go so well

together. This is simply a better and more logical way to design and manage our systems to emulate the nourishing systems that support all life. Examples include:

- **Biomimicry materials:** Spiber, a Japanese company, has managed to emulate the recipe of spider silk, making a range of tough and lightweight materials that are built out of proteins, but can be used for highly functional applications such as shock-absorption. Spider silk is five times stronger than steel and more flexible than nylon, yet it’s made at the cold-blooded temperature of a spider, out of dead insects and water. Prior to Spiber’s materials’ innovation through biomimicry, the nearest equivalent to spider silk made by humans was Kevlar, which is made by boiling petrol in sulfuric acid and then extruding it at high pressure. This is one of many examples of how biomimicry could yield highly functional materials that are made using low-temperature life-friendly recipes.

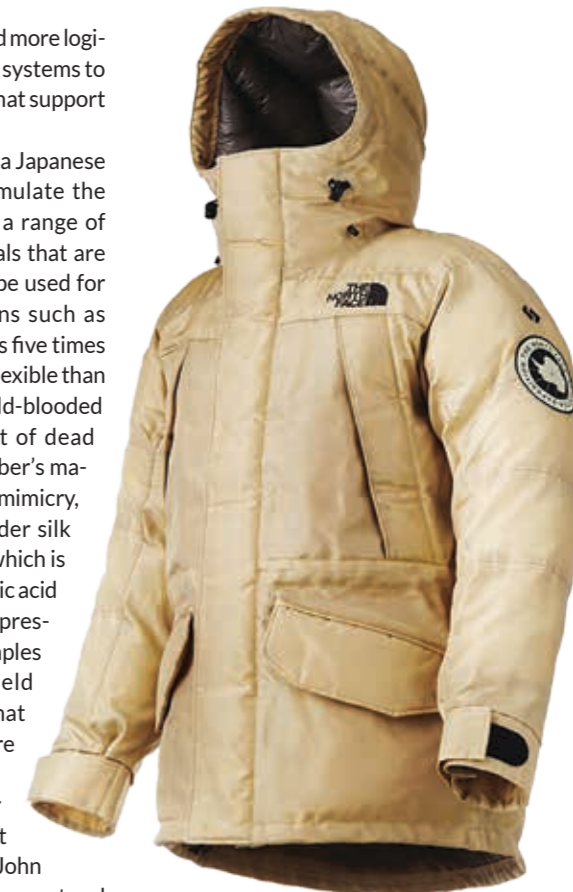
- **Biomimicry processes:** Rather than using chemicals to treat wastewater, Eco-Machines by John Todd Ecological Design mimic a natural ecosystem where a diverse set of interacting organisms clean contaminated water via naturally occurring processes.

Components of this natural ecosystem collectively contain organisms from all five kingdoms of life. Aquatic and wetland plants, bacteria, algae, protozoa, plankton, snails and other organisms are used in the systems to provide specific cleansing functions as part of a balanced food-chain.

Wetlands are one of the main kinds of ecosystems imitated in Eco-Machines, as they typically contain water-loving plants that thrive in high-nutrient environments. Other Eco-Machine designs mimic soil eco-systems and all of them use biodiversity as a fundamental to their designs.

- **Biomimicry systems:** “Why can’t we design our city infrastructure to provide ecosystem services rather than relying on external ecosystems to provide these? “Biomimicry Ecological Performance Standards are challenging cities to provide the same ecosystem services as the native ecosystems they cover over – can cities capture and cycle water, sequester carbon, clean the air and cycle critical nutrients in the same ways as native ecosystems do?”

“Work in this regard has been done for the city of Durban. Similarly, Interface Carpets is currently building a factory in Australia that aims to provide the same ecosystem services as the native ecosystem where it is being built. So instead of the built environment striving to minimise



Biomimicry materials specialist, Spiber, with Goldwin Inc, the distributor of The North Face brand, have produced a concept ‘Moon Parka’ using synthetic silk from proteins that mimic spider silk.

its impact, the built environment contributes to the ecosystems in which it is situated. Cities can act as water catchments themselves instead of relying on dams far away. Similarly they can capture their own energy and cycle their own wastes, transforming them back into value again and generating more and more economic opportunities in the process,” Janisch argues.

“Chemical engineers have a huge role to play in the potential shift in civilisation that comes from the emulation of nature’s materials, processes and systems. We are the ones that contribute to the design and scaling of currently toxic processes of human civilisation – mining, oil, plastics, textiles, pesticides, etc – as well as the generation of most of the waste and pollution from human systems – plastics in the ocean, pesticides in water-ways, air emissions, etc. But we also have the capacity to figure out how to reverse engineer and scale up more life-friendly biomimicry alternatives.

“If biomimicry thinking is adopted as a core tool in the chemical engineering toolbox, we can find solutions to many of the current systemic problems of our time and begin to develop materials and processes that are well-adapted to life on earth.” Janisch concludes. □



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