Biomimicry Explained

A CONVERSATION WITH JANINE BENYUS

1) What do you mean by the term "biomimicry"?

Biomimicry (from *bios*, meaning life, and *mimesis*, meaning to imitate) is a new science that studies nature's best ideas and then imitates these designs and processes to solve human problems. Studying a leaf to invent a better solar cell is an example. I think of it as "innovation inspired by nature."

The core idea is that nature, imaginative by necessity, has already solved many of the problems we are grappling with. Animals, plants, and microbes are the consummate engineers. They have found what works, what is appropriate, and most important, what *lasts* here on Earth. This is the real news of biomimicry: After 3.8 billion years of research and development, failures are fossils, and what surrounds us is the secret to survival.

Like the viceroy butterfly imitating the monarch, we humans are imitating the best and brightest organisms in our habitat. We are learning, for instance, how to harness energy like a leaf, grow food like a prairie, build ceramics like an abalone, self-medicate like a chimp, compute like a cell, and run a business like a hickory forest.

The conscious emulation of life's genius is a survival strategy for the human race, a path to a sustainable future. The more our world looks and functions like the natural world, the more likely we are to endure on this home that is ours, but not ours alone.

2) Can you give us an example of the kinds of problems we can solve through biomimicry?

Biomimics are looking to nature for specific advice: How will we grow our food? How will we harness energy? How will we make our materials? How will we keep ourselves healthy? How will we store what we learn? How will we conduct business without drawing down nature's capital?

Let's take a look at one of these categories: materials. Right now, we use what's called "heat, beat, and treat" to make materials. Kevlar, for instance, the stuff in flak jackets, is our premier, high-tech material. Nothing stronger or tougher. But how do we make it? We pour petroleum-derived molecules into a pressurized vat of concentrated sulfuric acid, and boil it at several hundred degrees Fahrenheit. We then subject it to high pressures to force the fibers into alignment as we draw them out. The energy input is extreme and the toxic byproducts are odious.

Nature takes a different approach. Because an organism makes materials like bone or collagen or silk right in its own body, it doesn't make sense to "heat, beat, and treat." A spider, for instance, produces a waterproof silk that beats the pants off Kevlar for toughness and elasticity. Ounce for ounce, it's five times stronger than steel! But the spider manufactures it in water, at room temperature, using no high heats, chemicals, or pressures. Best of all, it doesn't need to drill offshore for petroleum; it takes flies and crickets at one end and produces this miracle material at the other. In a pinch, the spider can

even eat part of its old web to make a new one.

Imagine what this kind of a processing strategy would do for our fiber industry! Renewable raw materials, great fibers, and negligible energy and waste. We obviously have a lot to learn from an organism that has been making silk for some 380 million years.

The truth is, organisms have managed to do everything we want to do, without guzzling fossil fuels, polluting the planet, or mortgaging their future. What better models could there be?

3) Your book expresses a sense of urgency. Why is it crucial to explore biomimicry now?

We humans are at a turning point in our evolution. Though we began as a small population in a very large world, we have expanded in number and territory until we are now bursting the seams of that world. There are too many of us, and our habits are unsustainable.

Having reached the limits of nature's tolerance, we are finally shopping for answers to the question: "How can we live on this home planet without destroying it?"

Just as we are beginning to recognize all there is to learn from the natural world, our models are starting to blink out-not just a few scattered organisms, but entire ecosystems. A new survey by the National Biological Service found that one-half of all native ecosystems in the United States are degraded to the point of endangerment. That makes biomimicry more than just a new way of viewing and valuing nature. It's also a race to the rescue.

4) Biomimicry seems to make so much sense. Why didn't we think of it years ago?

Well, actually, biomimicry as an approach to innovation is not new. Indigenous peoples relied heavily on the lessons and examples of the organisms around them. Alaskan hunters still stalk seals in exactly the same way that polar bears do, for instance. Many early Western inventions, such as the airplane and the telephone, also took their inspiration directly from nature.

What I do see is biomimicry cropping up *again* after a long hiatus of hubris brought on in part by the "better living through chemistry" era.

As we learned to synthesize what we needed from petrochemicals, we began to believe we didn't need nature, and that our ways were superior. Now, with the advent of genetic engineering, some of us have come to fancy ourselves as gods, riding a juggernaut of technology that will grant us independence from the natural world.

The rest of us, of course, are finding it hard to ignore the emergency sirens wailing all around us. Here at the end of the twentieth century, environmental reality is setting in, *pushing* us to find saner and more sustainable ways to live on Earth. Equally important is what is *pulling* us towards biomimicry-that is, our deepening knowledge of how the natural world works.

Biological knowledge is doubling every five years, growing like a pointillist painting toward a

recognizable whole. For the first time in history, we have the instruments-the scopes and satellites-to feel the shiver of a neuron in thought or watch in color as a star is born. When we combine this intensified gaze with the sheer amount of scientific knowledge coming into focus, we suddenly have the *capacity* to mimic nature like never before.

5) One of the more radical ideas put forth pertains to a new form of agriculture that models itself on plant communities that are indigenous to the ecosystem. How realistic is this? And is this really new?

Natural systems agriculture looks at a landscape and says "What grows here naturally?" In the midwest, it's the prairie. For 5000 years, the prairie has done a great job of holding the soil, resisting pests and weeds, and sponsoring its own fertility, all without our help. The secret of the prairie is that it is composed of perennial plants growing in polycultures (many species in the same field).

Unfortunately, we can't eat a prairie. Over the last 100 years, we have plowed up the prairie and replaced it with our own agriculture, based on annual plants grown in monocultures (one species for miles). Unlike the prairie's perennial polycultures, these annual monocultures do need our help.

Using annuals means we have to plow each year, which leads to soil erosion. To make up for poorer soil, we pour on tons of chemical fertilizers. To protect our all-you-can-eat monocultures from pests, we heap on oil-based pesticides. It works out to about 10 kilocalories of petroleum to produce one kilocalorie of food.

The way to get off this "treadmill of vigilance", says Wes Jackson of the Land Institute, is to breed perennial crops that we can eat and grow them in a prairie-like polyculture. Jackson's edible prairie would not merely be new; it would be the polar opposite of what we have now. The plants would overwinter, so we wouldn't need to plow and plant every year, or worry about soil erosion. We wouldn't need to add synthetic fertilizers because nitrogen-fixing plants would be in the mix. We wouldn't need to spray biocides because the presence of lots of different plant species would slow down pest outbreaks..

What we would have, instead of an extractive agriculture that mimics industry, is a self-renewing agriculture that mimics nature.

Though radical, this idea of breeding a prairie you can eat is quite realistic, when you consider that most of our crops were bred from perennial wild relatives. Over ten thousand years, we turned them into annuals and narrowed their genetic pools. So now we are looking to widen those genetic pools and breed perennial traits back into edible grains.

Right now, natural systems agriculture is at the Kitty Hawk stage-the researchers have proven the agricultural equivalent of drag and lift. Working alone, they will need 25-50 years of wind tunnel tests before domestic prairies can be planted in the Breadbasket. If they get support, the shift could come a lot sooner. It depends on what kind of research we as a society choose to fund. As Chuck Hassebrook of the Rural Affairs Center points out, research is a form of social planning.

6) What will prevent humans from, as you say, "stealing nature's thunder and using it in the ongoing campaign against life?"

That's a good question, because any technology, even if it's a technology inspired by nature, can be used for good or bad. The airplane, for instance, was inspired by bird flight; a mere eleven years after we invented it, we were bombing people with it.

As author Bill McKibben says, our tools are always employed in the service of an ideology. Our ideology-the story we tell ourselves about who we are in the universe- has to change if we are to treat the living Earth with respect.

Right now we tell ourselves that the Earth was put here for our use. That we are at the top of the pyramid when it comes to Earthlings. But of course this is a myth. We've had a run of spectacular luck, but we are not necessarily the best survivors over the long haul. We are not immune to the laws of natural selection, and if we overshoot the carrying capacity of the Earth, we will pay the consequences.

Practicing ethical biomimicry will require a change of heart. We will have to climb down from our pedestal and begin to see ourselves as simply a species among species, as one vote in a parliament of 30 million. When we accept this fact, we start to realize that what is good for the living Earth is good for us as well.

If we agree to follow this ethical path, the question becomes: how do we judge the "rightness" of our innovations? How do we make sure that they are life-promoting? Here, too, I think biomimicry can help. The best way to scrutinize our innovations is to compare them to what has come before. Does this strategy or design have a precedence in nature? Has something like it been time-tested long enough to wear a seal of approval?

If we use what nature has done as a filter, we stop ourselves from, for instance, transferring genes from one class of organism to another. We wouldn't put mammalian growth genes into a potato plant, for instance. Biomimicry says: if it can't be found in nature, there is probably a good reason for its absence. It may have been tried, and long ago edited out of the population. Natural selection is wisdom in action.

7) When you refer to business, you talk about the need to "shift our niche." What do you mean by that?

A "niche" is a profession in the ecosystem. Right now, we humans are filling a pioneering niche. We are acting like the weeds in a newly turned farmer's field. These weeds move into a sun-filled space and use nutrients and water as quickly as they can, turning them into plant bodies and plenty of seeds. They are annuals; they don't bother to put down winter roots or recycle because their moment in the sun is short. Within a few years, they'll be shaded out by the more efficient, long-lasting perennial bushes and shrubs. That's why they produce so many seeds; they're always on to the next sun-drenched horn of plenty.

Back before our world was full, and we always had somewhere else to go, this colonizing "Type I"

strategy allowed us to stay one step ahead of reality. These days, when we've gone everywhere there is to go, we have to forget about colonizing and learn to close the loops.

Closing the loops means trying to emulate the natural communities that know how to stay put without consuming their ecological capital. Mature ecosystems such as oak-hickory forests are masters of optimizing, rather than maximizing, throughput. They recycle all their wastes, use energy and materials efficiently, and diversify and cooperate to use the habitat without bankrupting it. Ecologists call these Type III communities.

Industrial ecologists are trying to glean lessons from natural communities to actually shift our economy from Type I to Type III. From ragweeds to redwood forests.

The latest business consultants in this field are people fresh from gorilla counts and butterfly surveys. I never thought I'd see the day, but it's true: the Birkenstocks are teaching the suits.

8) How would a Biomimetic Revolution come about?

In the book I talk about one possible path to biomimicry, which is modeled after my own experience in trying to renew an aging pond. The steps are simple but profound in their implications: They are 1. Quieting human cleverness, 2. Listening to nature, 3. Echoing nature, and 4. Protecting the wellspring of good ideas through stewardship.

Quieting human cleverness involves the maturing of the human race, the acknowledgment that nature knows best. I think we are coming closer to this. We are seeing that our cleverness has painted us into some corners, and we are open for suggestions.

Listening to nature is the discovery step. It's important that we interview the flora and fauna of the planet in an organized way. Out of the estimated 5 to 30 million living species on Earth, only about 1.4 million have been named! I would love to see Clinton and Gore create a Biological Peace Corps where people can volunteer to inventory biodiversity for two years. I'd also love to see systematics, which is the in-depth study of animal and plant groups, become a sought-after career again. We need people who know all there is to know about particular branches of nature's tree.

This step of closely listening to nature is not just for scientists, however. We all need to become ecologically literate, and the best way to do that is to immerse ourselves in nature, in childhood and as adults.

Echoing nature is where we actually try to mimic what we discover. Echoing nature will take a cross-fertilization of ideas. The technologists who invent products and systems need to interact with biologists so they can match human needs with nature's solutions. Task forces and formal societies would allow for periodic interactions, but for more permanent collaborations, we should design university departments in biomimicry.

I can also see using the Internet as a place to store our information. A giant database of biological knowledge would serve as an innovation matchmaking service. An engineer charged with designing a new desalination device, for instance, could easily review the strategies of the mangrove-a tree that filters seawater with its solar-powered roots.

Stewardship of wild and settled places should be the natural outgrowth of a biomimetic worldview. Once we see nature as a source of inspiration, a mentor, our relationship with the living world changes. We realize that the only way to keep learning from nature is to safeguard naturalness, which is the source of those good ideas.

9) How would a Biomimetic Revolution change our lives?

"Doing it nature's way" has the potential to change the way we grow food, make materials, harness energy, heal ourselves, store information, and conduct business. In each case, nature would be model, measure, and mentor.

Nature as model. We would manufacture the way animals and plants do, using sun and simple compounds to produce totally biodegradable fibers, ceramics, plastics, and chemicals. Our farms, modeled on prairies, would be self-fertilizing and pest-resistant. To find new drugs or crops, we would consult animals and insects that have used plants for millions of years to keep themselves healthy and nourished. Even computing would take its cue from nature, with software that "evolves" solutions, and hardware that uses the lock-and-key paradigm to compute by touch.

In each case, nature would provide the models: solar cells copied from leaves, steely fibers woven spider-style, shatterproof ceramics drawn from mother-of-pearl, cancer cures compliments of chimpanzees, perennial grains inspired by tallgrass, computers that signal like cells, and a closed-loop economy that takes its lessons from redwoods, coral reefs, and oak-hickory forests.

Nature as measure. Beside providing the model, nature would also provide the measure-we would look to nature as a standard against which to judge the "rightness" of our innovations. Are they life promoting? Do they fit in? Will they last?

Nature as mentor. Finally, our relationship with nature would also change. Instead of seeing nature as a source of raw materials, we would see nature as a source of ideas, as a mentor. This would change everything, ushering in a new era based not on what we can *extract* from nature, but on what we can *learn* from her.

When we view nature as a source of ideas instead of goods, the rationale for protecting wild species and their habitats becomes self-evident. To have more people realize this is my fondest hope.

In the end, I think biomimicry's greatest legacy will be more than a stronger fiber or a new drug. It will be gratitude, and from this, an ardent desire to protect the genius that surrounds us.

top of page