INTERVIEW WITH JANINE BENYUS

With our increased capacity and sophisticated scientific tools, we have the opportunity to align ourselves more closely with nature than ever before. What do you think?
More powerful micro and macro scopes are allowing us to see the inner workings of a dragonfly's wing, and to watch in color as a star is born. As biological knowledge doubles every few years, we have more information to inspire us – more evolved designs and strategies we can learn from. That's a great trend pulling us toward new kinds of innovation. At the same time, our tools are feeding back disturbing news: the double-glazing of the earth, the toxins that we're swimming in, the water shortages. As organisms, we're feeling biologically vulnerable again, but in this case it's not the saber tooth tiger that's threatening our lives. It's us. And that discomfort is providing the push toward innovation. We're realizing that we need to change the way we've been living our lives.

Materials scientist Mehmet Sarikaya has said, "We are on the brink of a materials revolution that will be on par with the Iron Age and the Industrial Revolution. We are leaping forward into a new age of materials. Within the next century I think biomimetics will significantly alter the way in which we live." Describe his work.
Mehmet studies a giant marine snail called abalone, whose mother of pearl interior, in addition to being incredibly beautiful and iridescent, is twice as tough as our high tech ceramics, which we still make today by the heat, beat and treat process. We heat kilns up to 4200 degrees Fahrenheit when we make ceramics. The abalone shell doesn't do this, of course. So Mehmet wondered if we could make materials at seawater temperature. The real breakthroughs now are coming in the area of self-assembling materials that mimic the way the abalone creates its puff pastry architecture of hard mineral and soft polymer. Jeff Brinker, who's at the Sandia National Laboratories in Albuquerque, New Mexico, works in the area of self-assembling materials. This will be the way we make products in the future. It's coming.

What did you learn from the late bio-computing futurist Michael Conrad?
Michael Conrad felt that every cell in our body is a sophisticated computer, in the sense that it is taking in inputs all the time. But it computes with these self-assembling, three-dimensional molecules that jigsaw together. This is computing through shape, a completely different paradigm than computing with ones and zeroes on silicon. This is computing on carbon, also known as wet computing.

What sort of work is going on at Arizona State University in Tempe that could revolutionize our energy industry?
There's a group of 25 scientists or so who work at the Center for Early Events in Photosynthesis, who study the first few pico-seconds, literally. They're mimicking a cell and doing chemistry with sunlight.

What does it mean to grow food like a prairie?
Wes Jackson runs a research organization called The Land Institute in Salina, Kansas. He realized that industrial agriculture is a failure because it grows miles and miles of annual plants in a monoculture. To plant annuals, you have to dig up the soil each year with tractor diesel, leading to massive erosion. To recoup fertility, you add fertilizer made from natural gas. The monoculture is an all-you-can-eat restaurant for plants, so you add pesticides, another fossil fuel product! It's ten kilocalories of oil for every kilocalorie of corn. He asked, "What if we were to learn from the prairie next door?" A prairie is a perennial polyculture, so for 27 years he's been trying to perennialize our major crops and plant them in mixtures. His scientific staff now is world class. But, of course, he could use lots more scientists working on this.

Let's play a word association game. Hummingbirds.
Poster child for sustainability. In the process of getting the fuel they need through nectar, hummingbirds manage to pollinate flowers, which ensures that there will be fuel next year for them or for other hummingbirds. That's the kind of system I would like us to have at our gas stations.

Chimpanzees.
Chimps are tremendous teachers in terms of what we should be eating. They are masters of smart eating, and now we realize that they self-medicate. They're able to choose certain plants in particular bushes and prepare them in particular ways to heal themselves. Howler monkeys pick plants that will actually bring on fertility during the reproductive stage, or delay it. So they seem to have not just self-medication going on but also birth control.

Purple bacteria.
A very ancient kind of bacteria that's being studied because they photosynthesize. They also have a pump within them that would make hydraulic engineers jealous. When lit by the sun, it pumps ions through its membrane, upstream, against gradient.

Rhinoceros horns.
Rhinos dig with their horns and use them as swords to spar with. If they get a crack in the

horn, it's a problem. Surprisingly, we found that they don't seem to get cracks in the horn, and if they do, the cracks seem to heal up. When there's a crack, the material around the crack disassembles, pours into the crack and then reassembles. We have no idea how this happens because there are no living cells in the horn. It's made entirely of dead hair! We're looking at it as a model for self-healing structures.

In my materials research, I've come across the work of Scott White at the University of Illinois at Urbana-Champaign. He's working with self-healing plastic.

Yes. There are self-healing plastics and self-healing concretes. We basically put little capsules of an epoxy, of a glue-like material, that when the concrete flexes will break and pour into the crack. It's an exciting but crude approximation of the amazing process that goes on in rhino horns.

Coral reefs.

Well, besides the fact that they're bleaching worldwide, which is a very big problem, coral reefs are a tremendous model of what's called a Type 3 ecosystem. A Type 1 ecosystem is an ecosystem that's temporary, like a carpet of weeds in an open field. Berry bushes move in and then eventually it's a forest. Now, a mature forest – like a coral reef – is a Type 3 ecosystem. These are complex communities, an incredible society of organisms that are in deep symbiosis with one another. Business managers are looking at these Type 3 systems, believe it or not, as a model for a new way to organize our whole economy so that it's much more interconnected, interdependent, and less of the competitive model that has a lot of inherent waste in it. More and more, it's about the closed loop, tightly woven food web, where nothing is wasted; there's always somebody there to catch that next little particle of food and use it.

Have we been successful in mimicking spider silk yet?

This incredible material is five times stronger than steel. In *Biomimicry* I wrote about researchers who were very keen to figure out how to make this fibre the way a spider does – in water and at room temperature. Without petroleum, without heating it up, without sulfuric acid. Since then, Montreal-based Nexia Biotechnologies has decided to take the gene out of the spider and put it into a goat and then have the goat milk the protein, which turns into the fibre. The transgenic goat milks the protein from its mammary gland. And then the goat gets cloned. Gene transfer from spiders to goats doesn't happen in the natural world! Besides, this is just domestication with a twist. To truly emulate would be to find the recipe, find the way to manufacture in water at room temperature, like Jeff Brinker did with abalone. We need to find the recipe and cook it in our own kitchen, and leave the organisms alone. That to me is true biomimicry.

Janine Benyus is the author of Biomimicry: Innovations Inspired by Nature.