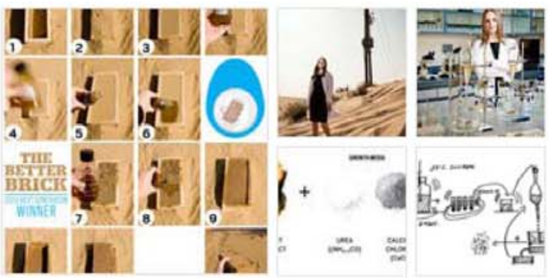

The Better Brick: 2010 Next Generation Winner

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This year's winner—a bioengineered brick, conceived by a young American architect—may be modest in physical scale, but it has the potential for global impact.

By Suzanne LaBarre

Brick built the ancient citadels and hypocausts of the Indus Valley and ornamented the Chrysler Building, that great monument to the machine age. But in recent years, it has had a more sinister legacy: environmental menace. Tossing a clay brick into a coal-powered kiln, then firing it up to 2,000˚F, emits about 1.3 pounds of carbon dioxide. Multiply that by the 1.23 trillion bricks manufactured each year, and you're talking about more pollution than what's produced by all the airplanes in the world. The winner of the 2010 *Metropolis* Next Generation Design Competition proposes a radical alternative: don't bake the brick; grow it.

In a lab at the American University of Sharjah, in the United Arab Emirates, Ginger Krieg Dosier, an assistant architecture professor, sprouts building blocks from sand, common bacteria, calcium chloride, and urea (yes, the stuff in your pee). The process, known as microbial-induced calcite precipitation, or MICP, uses the microbes on sand to bind the grains together like glue with a chain of chemical reactions. The resulting mass resembles sandstone but, depending on how it's made, can reproduce the strength of fired-clay brick or even marble. If Dosier's biomanufactured masonry replaced each new brick on the planet, it would reduce carbon-dioxide emissions by at least 800 million tons a year. "We're running out of all of our energy sources," she said in March in a phone interview from the United Arab Emirates. "Four hundred trees are burned to make 25,000 bricks. It's a consumption issue, and honestly, it's starting to scare me."

This year's Next Generation competition asked entrants to invent a "small (but brilliant and elegant) 'fix'" for the designed environment. Jurors saw space-saving clothes hangers and solar-powered window shades and souped-up planters. Dosier's bricks are certainly small—in lab tests so far, about the size of a Lego—but with further research, their impact could resonate all over the world. Consider the prospects in countries like China and India, where outdated kilns put brick production among the top coal consumers. "There was a strong feeling among the judges that the award should go to someone dealing with an issue on a global scale," says Chris Sharples, a juror and a principal of SHoP Architects. "Here was a very simple concept defined by scientific method and an example of how you can come up with some very innovative ways to solve basic problems." Choosing it as the winner was, he adds, a "no-brainer." It was also a testament to the value of an architect who knows her way around a microscope.

Dosier, 32 years old, isn't the first to dabble at the crossroads of microbiology and chemistry. In Precambrian times, bacteria created geological formations through a process that scientists would only begin simulating 3.45 billion years later, growing ground-firming minerals in oil patches and contaminated soil. Nor is she alone in trying to green the humble brick. Intrepid entrepreneurs have tamped everything from fly ash and plant refuse to car tires and plastic bottles into a neat little block and called it a brick (thoroughly peeving the brick industry, which will tell you that anything short of clay and shale is just a cheap imitation). Dosier's act of alchemy was to apply science to design. "There are thousands of examples of microbial mineral precipitation in the scientific literature, but few if any of them have been explored for use in fabrication of construction or design materials," Grant Ferris, a geology professor at the University of Toronto, who conducted early MICP studies, writes in an e-mail. "This is what makes Professor Dosier's work so compelling. Bioremediation and industrial applications look out!"

The first lines of Dosier's résumé would hardly peg her for a chemistry nerd: an undergraduate degree in interior architecture from Auburn; a semester at Rural Studio under Sam Mockbee, who sermonized, Messiah-like, about "architecture as kindness"; a master's in architecture at Cranbrook, the free-flowing essence of everything hard science isn't. Just before graduate school, Dosier threw away her worldly possessions—her clothes, her typewriting tables, her precious antique glassware. In retrospect, it's when much of her thinking about materials in design took shape. "I was questioning this idea of ownership, and I got really interested in chemical processes, researching what materials are made of, what you can add to them to change how they grow and die," she says. Soon, she was building furniture out of salt and calcium carbonate (a compound found in shells), then watching it evaporate in the forest like an Andy Goldsworthy sculpture. Her master's thesis, a salt-composite handrail, cleaned germs off anyone who touched it, before wearing away to a flimsy scaffold. "I wanted to show," she says, "that architecture can do more than just exist."

To develop her ideas further, she needed a firmer grasp of the technology. So she did what any aspiring scientist would have done: she headed to the toy store and bought crystal-growing kits. Lots of them. "My favorite was a crystal-geode kit, where you seeded plaster of Paris with crystals and placed it in an aqueous solution of crystal-growth media," she says. The kits taught her invaluable chemistry basics: keep your solution wet (otherwise nothing will grow) but not too wet (otherwise nothing will grow), and keep the room cool (otherwise nothing will grow) but not too cool (otherwise nothing will grow). And so on.

This informal education continued apace at North Carolina State University, where she landed a visiting professorship in 2005. She audited classes on materials science and pored over books like *Bio-mineralization: Progress in Biology, Molecular Biology and Application*. By then, she had familiarized herself with research on growing solids for industrial uses and knew she wanted to adapt it for architecture. She sought out mentors, including the microbiologist José Bruno-Bárcena, who became, in matters of scientific inquiry, the Anne Sullivan to her Helen Keller. "From an architecture–interior design background, I always wanted to go big, and my experiments would fail 98 percent of the time," Dosier says. "I felt like I needed to buy *Chemistry for Dummies*. He started opening the door of my mind on how to think." Bruno-Bárcena encouraged her to narrow her focus. When she announced she wanted to grow brick via microbes in either waste mineral water or a porous skeleton, he suggested she limit herself to the latter. Another mentor, James Patrick Rand, an NCSU architecture professor, convinced her to train her attention on developing basic bricks instead of more complex building forms. Like Bruno-Bárcena, he saw value in simplicity. All the while, she read: *Introduction to Industrial Minerals*; *Microbial Sediments*; *Biomineralization: Cell Biology and Mineral Deposition*. "Ginger is not at all fearful of the science of construction materials," Rand says. "She readily engages chemical processes —things many architecture students and practitioners are afraid of."

It's true: architects don't do this sort of thing. In a great disservice to themselves and their profession, they avoid science the way poets avoid calculators. "Typically, architects are not involved in the development of building products and sustainable technologies," SHoP's Sharples says. "We rely on experts outside the field, so often these green products are just applied directly to our designs." Put another way, when architects have a hand in producing new materials, they exert more control over how buildings perform. That is Dosier's coup.

Yet for all her toil, her first successful experiment was somewhat accidental. At the University of Sharjah, where she moved in 2007 to teach full-time, she spent two years trying to develop a brick with different microbes, material proportions, and pH levels. Everything failed.

(It didn't help matters that the first bacteria cultures she bought from India and the U.S. Department of Agriculture were duds.) Then one afternoon, she threw together a bunch of scraps from some old, ill-fated tests, for kicks. Practically forgetting about it, she revisited experiment No. 112 a week later, only to discover that the medium had transformed into a "baby brick," as she tells it, a four-by-two-by-one-centimeter proof of concept. "I was shocked to find that it had worked," she says, "and glad that I took detailed lab notes." The magic formula was in allowing the right concentration of bacteria to fester just long enough.

The months since have been an exhaustive exercise in reproducing and strengthening the results. She has repeated the combination more than 30 times, experimenting with assorted sand grains and aggregates, like recycled glass. She has also explored various manufacturing techniques. Traditional casting is the most obvious method, since it requires few resources—formwork, sand, bacteria, and the calcium chloride–urea solution, almost all of which is available locally, both in New York and in the UAE. Rapid prototyping is another, decidedly less democratic option. In the future, Dosier says, she'll be able to program the brick's precise composition, then fabricate it layer by layer on a 3-D printer. The technology poses countless design possibilities. Ball-shaped bricks: Why not?

The future poses countless obstacles, too. She'll have to figure out how to create a strong brick without squandering raw materials, and how to scale up for mass production given that the chemical process is inherently slow. (Dosier's blocks take a week to grow; clay bricks can be made in two days.) But the most pressing hurdle is that the biobrick pollutes. Microbial-induced calcite precipitation spews tremendous amounts of ammonia, as scientists affiliated with Delft University of Technology, in the Netherlands, discovered recently when they tried the chemical process on contaminated sand and soil. "High ammonia concentrations result in environmental eutrophication and eventually, via microbial conversion to nitrate, the poisoning of groundwater," the Delft researcher Henk Jonkers writes in an e-mail. If the bacteria continues to convert ammonia to nitrous oxide, he adds, it can produce a greenhouse gas 320 times more powerful than CO_2. "The results show that working with natural processes is not necessarily equivalent to sustainable practices!"

Dosier plans to capture emissions before they transform into noxious gases. A closed-loop system would recycle waste back into the brick-production cycle using organic buffers (carbon filters, for example), though she acknowledges that it would require "collaborations with additional researchers and scientists in various fields of environmental study and industrial ecology." (Crystal-growing kits can't do everything.) A regular designer would've bowed out of the game by now. But Dosier, versed as she is in the methods of both science and design, welcomes—and is perhaps ideally suited to overcome—the challenge.

In the meantime, she dreams about actually putting the bricks to use. She wants to field-test them on a large expanse of desert north of the UAE–Saudi Arabia border, where Bedouins, the seminomadic tribes who populate the Middle East's sandy wilds, hitch their camels seasonally. And a friend from Cranbrook, who works in humanitarian aid, invited Dosier to join him in Ethiopia this summer to "get this material going." A rash of violence ahead of this month's elections postponed the trip indefinitely, but Dosier remains optimistic.

"Even if [Ethiopia] doesn't work out, I can think of plenty of regions here where I would like to work," she says. "The lab is fun to work in. But seeing if it could really happen? That for me is the whole deal." Maybe then, brick buildings will no longer be villains of the green age but monuments to it.