ALMOST CERTAIN

creation of life

Synthetic biology remakes organisms, but can it bring inanimate matter to life? *By David Biello*

A scientist adds a few chemical compounds to a bubbling beaker and gives it a swirl. Subtle reactions occur, and, lo and behold, a new life-form assembles itself, ready to go forth and prosper. Such is the popular imagining of synthetic biology, or life created in the lab.

But researchers in this field are not as interested in animating the inanimate. In fact, scientists remain far from understanding the basic processes that could allow inert, undirected compounds to assemble into living, self-replicating cells. The famous Miller-Urey experiment of 1952, which created amino acids from primordial goo, remains difficult to replicate conclusively.

Rather synthetic biology today is about modifying existing organisms. It can be seen as genetic engineering on steroids: instead of replacing one gene, synthetic biologists modify large chunks of genes or even entire genomes. The change in DNA can force organisms to churn out chemicals, fuels and even medicines. "What they're doing is constructing from scratch the instruction set for life and adding that to something already alive, replacing the natural instruction set," explains biological engineer Drew Endy of Stanford University. "It defines an alternative path forward for promulgating life on earth. You no longer need to descend directly from a parent."

In that regard, some scientists do not see any reason to replicate an existing cell with a man-made one. "Making something as close as possible to an existing cell, you might as well use the existing cell," argues geneticist and technology developer George M. Church of Harvard Medical School. And manipulating genomes has become so widespread that even high schoolers do it.

Synthetic biology, in fact, is all about bringing the principles of large-scale engineering to biology. Imagine a world where bamboo is programmed to grow into a chair, rather than roughly woven into that shape through mechanical or human industry, or where self-assembling solar panels (otherwise known as leaves) feed electricity to houses. Or trees that exude diesel fuel from their stems. Or biological systems that are reengineered to remove pollution or to thrive in a changing climate. Reprogrammed bacteria might even be able to invade our bodies to heal, acting as an army of living doctors inside us.

"In principle, everything that is manufactured could be manufactured with biology," Church argues. It is already happening on a small scale: enzymes from high-temperature microbes used in laundry detergent have been reengineered to perform in cold water, thereby saving energy.

Synthetic biology "is going to fundamentally change the way we make everything for the next 100 years," predicts David Rejeski, director of the science, technology and innovation program at the Woodrow Wilson International Center for Scholars in Washington, D.C. "We can engineer matter at a biologically relevant scale. That's as big a change as the industrial revolution back in the 19th century."

With great promise comes great risk, too—namely, in the form of modified organisms escaping the lab. Most such creations today are too ungainly to survive in the wild. For more sophisticated creations in the future, synthetic biologists expect that various safeguards would need to be instituted, such as strict monitoring or a kind of self-destruct sequence in the new genetic code. Because scientists can entirely remake organisms at the genetic level, they can insulate them from natural systems, Endy says: "We can make them fail fast."

Nevertheless, some scientists are indeed attempting to re-create life. Carole Lartigue, Hamilton Smith and others at the J. Craig Venter Institute have made a bacterial genome from scratch and even turned one type of microbe into another. Researchers elsewhere have created synthetic organelles and even an entirely novel organelle, the so-called synthosome, to make enzymes for synthetic biology. Life from scratch may be imminent.

Such a feat does not mean scientists will understand how life arose in the first place, but it might provoke fears that humanity has achieved the undeserved power of deities. But the creation could also have a more humbling effect—by transforming our understanding of our fellow life-forms. "The benefits would be to remake our civilization in partnership with life at the molecular level to sustainably produce the materials, energy and feedstocks we need," Endy says. "We will have a balance of partnership with the rest of life on the planet in a way that is very different from the way we now interact with nature."

room-temperature superconductors

50–50

They would transform the grid—if they can exist at all *By Michael Moyer*

You can build a coal-fired power plant just about anywhere. Renewables, on the other hand, are finicky. The strongest winds blow across the high plains. The sun shines brightest on the desert. Transporting that energy into cities hundreds of kilometers away will be one of the great challenges of the switch to renewable energy.

The most advanced superconducting cable can move those megawatts thousands of kilometers with losses of only a few percent. Yet there is a catch: the cable must be kept in a bath of liquid nitrogen at 77 kelvins (or –196 degrees Celsius). This kind of deployment, in turn, requires pumps and refrigeration units every kilometer or so, greatly increasing the cost and complexity of superconducting cable projects.

Superconductors that work at ordinary temperatures and pressures would enable a truly global energy supply. The Saharan sun could power western Europe via superconducting cables strung across the floor of the Mediterranean Sea. Yet the trick to making a room-temperature superconductor is just as much of a mystery today as it was in 1986, when researchers constructed the first superconducting materials that worked at the relatively high temperatures of liquid nitrogen (previous substances needed to be chilled down to 23 kelvins or less).

Two years ago the discovery of an entirely new class of superconductor—one based on iron—raised hopes that theorists might be able to divine the mechanism at work in high-temperature superconductors [see "An Iron Key to High-Temperature Superconductivity?" by Graham P. Collins; Scientific American, August 2009]. With such insights in hand, perhaps a path toward room-temperature superconductors would come into view. But progress has remained slow. The winds of change don't always blow on cue.