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Art Is Where You Grow It

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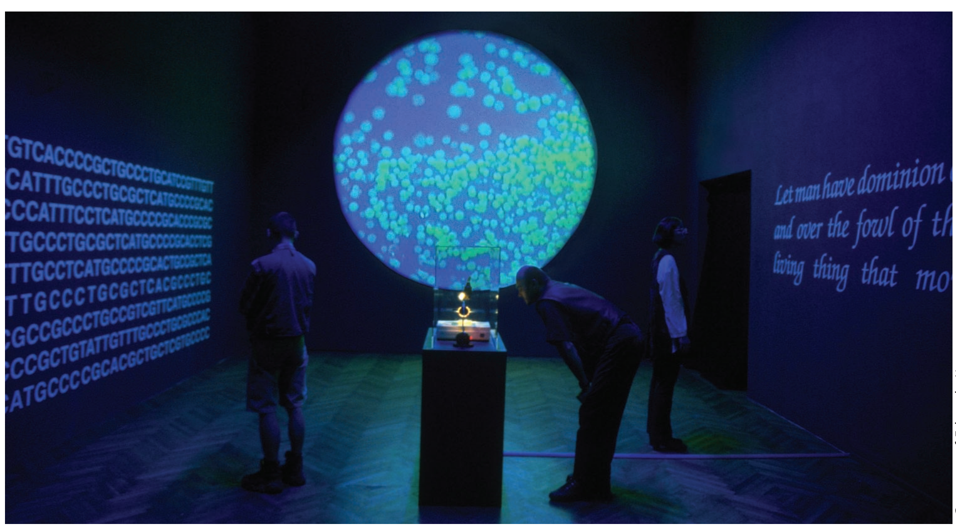
> I collected the instruments of life around me, that I might infuse a spark of being into the lifeless thing that lay at my feet.
>
> —*Dr. Frankenstein*

The urge to understand, alter, and yes, create life has colored human activity from the dawn of our race. Mary Shelley was one of the first writers to have her protagonist, Dr. Frankenstein, use a modern technology—electricity—to animate recycled body parts. Shelley's tale was a warning against hubris and, to some extent, against technology.

The urge to control life has not abated. Today, the sciences of molecular biology, genetic engineering, and DNA manipulation are the tools scientists and artists use. Neither scientists nor artists are expecting to create a human-like creature, yet. However, scientists have taken the first steps to successfully grow bladders and other organs. Artists are also modifying and growing living tissue to create high-concept, highly provocative, and highly controversial art.

Powerful examples

I was introduced to the modern version of monster-making at the annual Ars Electronica Festival (http://www.aec.at) and a show at Exit Art, a gallery in New York City, both last September. Exit Art's show, *Paradise Now* (http://www.geneart.org/pn-home.htm), featured about 40 artists and technologists "picturing the genetic revolution." Mostly a visual art show, it featured an interactive work by Eduardo Kac called *Genesis* that involved coding a line from the Old Testament book of Genesis ("Let man have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moves upon the earth") in DNA. Kac inserted the coded DNA into bacteria, which he showed on a microscope slide in a darkened room. Visitors could push a button to shine an ultraviolet light on the bacteria, causing genetic mutations and rearranging the coded message (see Figure 1). Kac, who created a sensation a couple of years ago by mixing genes for fluorescence with rabbit genes—creating a glow-in-the-dark bunny (Figure 2)—explained, "The ability to change the sentence is a symbolic gesture: it means that we do not accept its mean-



Courtesy of Eduardo Kac

Figure 1. Kac's* Genesis *installation lets visitors play God by rearranging bacterial DNA and the words of the book of Genesis at the same time.

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Courtesy of Eduardo Kac

Figure 2. Kac created a genetically modified rabbit, Alba, who glows when exposed to blue light at 488 nm wavelength.

ing in the form we inherited it, and that new meanings emerge as we seek to change it." Genesis proclaimed that humans have dominion, but the writer of that book could never imagine the power that we've attained.

Ars Electronica, a 20-year-old competition and conference held in Linz, Austria, focused this year on the topic of Next Sex. The proceedings were only mildly erotic, but the topic sizzled with the potential of transsexual, postsexual, and nonsexual reproduction, cloning, and tissue manipulation. The ideas and experiments presented were mind-boggling, combining biological, electronic, and computational gadgets and concepts. Like Dr. Frankenstein's work, they are at the same time fascinating and frightening.

Joe Davis is hoping ultimately to communicate with extraterrestrial life with genetically coded messages distributed throughout the galaxy. Although several technical feasibility issues still impede this scheme (not to mention plausibility issues), Davis has found ways to accomplish the first steps—encoding text and images in DNA and inserting that DNA into living hosts.

Davis has found that an unconventional education has served him well. After earning a BA in creative arts, he lectured on architecture at Massachusetts Institute of Technology (MIT) and there met Alexander Rich, a Sedgwick Professor of biophysics. In Rich's biochemistry and biophysics laboratory, Davis learned genetic biology, creating his first genetic art work, *Microvenus* in 1986.

Davis' thinking on the Search for Extraterrestrial Intelligence (SETI) project is that because rockets are so slow and expensive, we need a low-cost, high-volume medium. The medium must be extremely long-lived, because it might take our extraterrestrial neighbors hundreds of millions of years to find it. Davis believes he has found the medium in bacteria, some of which can survive the requisite time in space-like conditions. To use bacteria as a medium, Davis must "print" a message on a single-celled organism. He devised an efficient coding scheme using the four bases of DNA. This system makes it easy to convert between computer-friendly hexadecimal coding and the DNA-specific quaternary code. Davis inserts the DNA into the bacteria, which then integrates the coded DNA with its natural genetic material, creating a codex that the cognoscenti can read and decipher. In the mid 1990s, Davis demonstrated the method, coding an image of our own galaxy, the Milky Way, into a 3867-mer (the basic unit of DNA measurements, equal to one base pair) DNA strand (see Figure 3).

At Ars Electronica, Davis not only presented

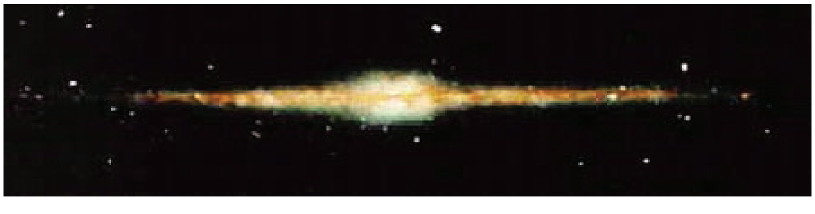

Figure 3. An image of our Milky Way galaxy was taken by the Cosmic Background Explorer (Cobe) satellite and encoded into DNA by Joe Davis.

Courtesy of Oron Catts, Ionat Zurr, and Guy Ben-Ary

Figure 4. Semiliving worry doll H symbolizes our fear of Hope. This is a digital image of a handcrafted worry doll made out of degradable polymers and surgical sutures. The image is of the doll before it was seeded with McCoy cells (small doll) , and after the tissue was grown and the polymer degraded inside the bioreactor (big doll).

some bacteria implanted with genetic messages, but he and his collaborator Katie Egan demonstrated a novel techno-toy, the Listening Microscope.

Davis and Egan noticed that paramecia and other single-cell creatures are extremely active. They wondered what all that swimming, crawling, eating, and dividing would sound like. (This reasoning is based on the principal that any motion that creates waves in its surrounding medium is making acoustic waves, or sound.) Using unique optical systems, Davis developed techniques that let him transduce the physical motion of these miniature creatures to sound that humans can hear.

Davis and Egan place the organisms on a special slide with a thick depression backed by a reflective coating. They use a dark field microscope setup (in which light enters the field from above), so that the organisms reflect light. Using plain white light and lasers, they can optically sense the motion of their subjects. They then convert that motion to sound.

Davis and Egan have their own farm, a menagerie of protozoa, rotifers, vorticella, and other microorganisms. They've found that each organism, indeed each species, sounds different from the others. This technology might someday enable people to monitor the health of a pond by "listening" to the sounds of its microscopic inhabitants.

On a larger scale

Oron Catz, Ionat Zurr, and Guy Ben-Ary are exploring other aspects of microbiology with artistic concepts and goals. Originally from Israel, all three spent time at the University of Western Australia, in Perth, and then at MIT, where Catz and Zurr are working now. In the Tissue Culture and Art project, this team is working with the product of DNA—living tissue. They're growing high-tech versions of worry dolls, which Guatemalan gradmothers make to sooth the children, out of what they call *semiliving tissue*—McCoy cells, a standard medical supply item that's living tissue from a monoclonal cell line bred into mice.

Catz saw a new medium and wondered about the impact of using it:

> How do people relate to objects that are partially grown and partially constructed? Our language is not equipped to deal with those entities; it's a new aspect of life. Belief systems are not equipped to deal with these ideas. The artist's job is to show new ways of thinking about this. We can't leave it up to scientists and technocrats. Artists can help bridge the gap between common knowledge and the laboratory. We can help people rethink values and concepts. We produce semiliving objects that blur the boundaries between what is alive and what is not. When we consider an animal dead, quite a lot of its cells are still alive. The line is not as sharp as we think it is; it's actually a continuum.

Investigating that continuum led to the Tissue Culture and Art project. Catz and his collaborators build armatures of inert, biodegradable polymer, which they hand fashion to resemble the abstract Guatemalan worry dolls (see Figure 4). The polymer scaffolding can be quite complex, and often the team adds nonorganic materials, which provide detail to the fairly simple worry dolls. The skeleton is "seeded" with living cells that multiply, replacing the polymer. The process takes place in bioreactors, artificial wombs designed to offset the pull of gravity by spinning the contents as the cells grow. The end result is a tiny doll, no more than 10-mm long, replete with facial features and costume.

These dolls have limited size and lifetimes. Because they have no circulatory system, they can grow only a few cells thick, allowing essential gases and fluids to diffuse through the tissue. Their lives are limited both by disease—they can become infected by other organisms—and by the artist's decision that it's time to stop. They might soon transcend these limits, as new techniques to grow capillaries might provide the circulatory system needed to bring nutrients and remove wastes from deeper tissue layers. Catz and his collaborators are also looking at the possibility of using fibroblasts from muscle tissue in their creations, which might enable their creations to move.

Dr. Frankenstein, I presume?

> I saw the dull yellow eye of the creature open; it breathed hard, and a convulsive motion agitated its limbs.
>
> —*Dr. Frankenstein*

The questions raised by these and other artists who use the most basic building blocks of life as their media go far beyond their works' artistic merits. In fact, religious, biological, political, and social issues tend to overshadow the artistic merits.

We often hear complaints about scientists and technicians who work in ivory towers, doing their work with no thought to the impact or consequences on a larger society. These artists have moved beyond organic materials such as clay, pigments, wood, and metal to a deeper level—organic tissues. But these artists are acutely aware of the society around them. Like their artistic antecedents, they're being intentionally provocative. Artists have traditionally explored new technologies. The cubists experimented with concepts proposed by quantum physics, and works visible only from space have emphasized the impact of leaving the planet. Television, computers, and the Internet have all inspired artists to push the boundaries of technology. In many cases, they provide trail-blazing services to the rest of the population as they explore the uses and costs of new technologies. Nearly every time new artistic ground is broken, a concerned chorus keens warnings of imminent doom.

So it is with these brave explorers of intercellular space. Although not yet fomenting the outcry that the developers of genetically modified food have engendered, they follow the same path, and opponents can make the same arguments for and against their work. The potential for danger seems real, even though that danger is statistically on par with the likelihood of being hit by lightening or winning a lottery. But people do win lotteries, and people are hit by lightening; both the public and these artists must consider the real, if slight, chance of an accident or error.

The safety issue is compelling. All the artists I talked with have tried to ensure that their creations are unable to exist outside of the tightly controlled environments in which they are conceived. For example, Davis adds multiple "stop" sequences to the DNA codes to ensure that they can't replicate.

Catz noted, "Our constructs cannot live outside of the lab. They are part of a complex organism. You can't cut off a finger and toss it down and expect it to take over the world. There is no conceivable way our constructs could escape into the environment or cause any harm."

He's probably right. However, there's a chance—conceivable if not actually measurable—that one of Kac's, Davis', or Catz's inventions could escape containment, breed independently, or infect some natural organism to spread around the planet. It's impossible to foresee the consequences of such an event. These creations could either be harmful or beneficial to the human species, or most likely, they would have no impact at all. Is this a risk we should take for the sake of art?

In the final analysis, the question is how we should judge this work. Is it science, or is it art? If it's science, do we want amateurs messing in this sandbox? If it's art, should we not compare it to other art and judge it on its beauty, profundity, and ability to make us consider new concepts? As art, I find it successful, distressing, and thought provoking. As science, it scares me. But the genie is out of the bottle. Now we must wait and see if it's a good genie or a bad one. **MM**

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