

# TECHONOMY

YEAR-END EDITION 2015



# Our digital capabilities can help bridge today's world with tomorrow's.

Today, technology can transform every aspect of your company. Now every business is a digital business. Our industry expertise, coupled with our integrated digital capabilities across interactive, analytics and mobility, can help you take advantage of the opportunity to innovate and compete. We can also manage your digital processes or take them to the cloud. All so your company will see tangible results from the virtual world. That's high performance, delivered.

High performance. Delivered.



What motivates us at Techonomy? Why is what we do uniquely necessary, when every magazine has a conference and every journalist seems to want to write about tech? Because despite all the febrile hype about startups, unicorns, billionaires, IPOs, and iPhones, we all need more understanding about what life really can be like in a tech-driven future.

We see business as Earth's best hope for progress. But nearly every company is struggling to accommodate today's realities—headlong industrial transformation, with established businesses paralyzed by the need to change even as many startups seem focused only on a quick hit.

Our moment is one of too much fear and not enough hope and confidence in the capacity of mankind, empowered by tech, to accomplish miraculous feats. With a planet straining at the seams, with five billion people still dramatically deprived compared to the affluent few, the prospects are not good unless we step up our game. At Techonomy we know tech can unite us, enlighten us, and help us all live longer, happier, friendlier, more hopeful lives. That is what gets us up in the morning.

In this magazine we explore the potential that technologized agriculture might feed everyone and that genomics could transform health care, the vistas that can open if we think holistically about design, and the possibility that a weird anonymous invention called the blockchain might actually prove the means by which growth takes off in the world's poorest countries. Some of these predictions could turn out to be wrong. All are challenging. But our work is to turn over all the possibilities and help leaders in every field and industry do the same.

We hope you'll join us by reading, here and at Techonomy.com and by participating in conversation online, at our conferences, at our dinners, in our offices and possibly in yours. We want to help more people develop faith that a better world is possible.

We all need to focus harder on how tech, and our own commitment, can help achieve it.



David Kirkpatrick



# TECHONOMY

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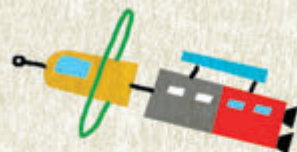
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After two days of talk our Techonomy 2014 audience needed to chill. Rockers Joe King, left, and Isaac Slade, who front The Fray, played an intimate acoustic set after an onstage conversation with Jon Healey of the Los Angeles Times.



# HOW WE *Re-Humanized* OUR PLANET

(A look back from 2065)

**BY SIMONE ROSS & GLENDA CUDABACK**



Towards the end of 2015, our world was in turmoil. Instability, fear, and anxiety dominated the global dialogue. A growing sea of refugees overwhelmed Europe and we were close to the point of no return with climate change that threatened to suffocate the planet (if an asteroid didn't get us first). Cyber-crime, espionage and



war raised geopolitical tensions.

The escalating clash of tradition with tech-led innovation contributed to a global atmosphere of pressure and spiritual collision. The tribe of young, global tech-lovers were butting head-on into centuries of deeply held, firmly entrenched religious, institutional and cultural practices. Only one global leader, the Pope, carried much weight with citizens around the world. Opti-

mists were rare. Anxiety reigned.

It wasn't until about 2028 that new heroes in interplanetary exploration and genetic innovation began to refocus the entire planet on real possibilities for a better world.

By 2044, "pollution" was no longer a problem, primarily because technological advances had rendered it an impossibility. Industries and infrastructures previously based on fossil fuels gave way to

fusion and superconductive, large-scale power systems. Nano-scale, self-regenerating fuel cells were embedded in nearly every material. We could convert noise pollution, manipulating sound waves, so it was harmlessly absorbed by the surroundings. Ship turbines no longer disturbed ocean migration patterns. Earth was returning to something resembling a pre-industrial age ecosystem, in which all

species could thrive.

All cities were rural. All farms were urban. The distinction between the two grew meaningless, and their pleasures became interchangeable. Food production (organic and synthetic) was mostly local.

We were well into the shift towards a political, social and economically borderless society, led and governed by the well-tested and wisest citizens (human, AI, and cyborg). They were in continuous contact with their constituencies through our planetary inter-sensory grid. Global economic interconnection and shared-reality systems made war almost inconceivable.

Politics had evolved into applied ethics, an information and engineering-based art, enhanced and constrained by a profoundly intrusive but ideologically benign interconnectedness.

As early as 2028, society had gained confidence in genetic editing and selecting personal enhancements. We started to achieve control over the design and maintenance of our bodies, our moods, and our general well being. Intellectual, physical, and neurological interventions began as global fads and soon became routine. Most major diseases were eradicated, programmed out of the human race by manipulating DNA.

Human reproduction was no longer left to chance as a by-product of sexual accident. Every child was a conscious and deliberate creation. Everyone had the means and motivation to be good parents.

By mid-century, remaining inequalities were neurological, with human potential and performance disproportionately affected by still

relatively rare and high-cost personalized neuro-technologies and human-machine interfaces.

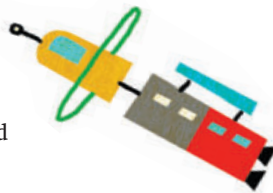
Finally our species began to achieve the intellectual, philosophical, and moral potential that for so many decades only resolute optimists had believed possible.

The arts now touch us in ways unimaginable to our predecessors, enhancing and reinforcing the best of humankind. Music evolved from evoking emotions to composing with emotions that morph into experiences. Old-fashioned human creativity and curiosity continue to improve how we relate, complementing the knowledge we gain from the knowledge markets. Bio-Artists have replaced the medical profession. The lifeforms we discover in deep space serve as new and exotic models for continuing bio-transformation.

In the '20s information technology became truly mobile. We moved beyond software that simply anticipated needs to a shared-reality system with absolute knowledge of needs. Our "devices" were micro-implanted. The "intel inside" was true intelligence, gleaned from nanoscopic sensors coursing through our bodies.

In 2040 the process of enhanced human evolution took a further leap when neurologists and engineers created total "sensory mobility," allowing individuals to "be" wherever they wanted, whenever they wished. Trivially inexpensive new energy sources helped underpin this system.

Our only obstacle to faster progress had been the lack of a reliable



global inter-sensory grid, the ultimate "Internet of Things," connecting our senses to whatever we wanted to do or feel.

Without it we had limited collective empathy. By 2045 the grid became good enough to serve as the heart of our interconnected polity.

With access now considered a basic right for all living things, we are able to be anywhere at any time. All primitive systems of transportation have been relegated to museums. Faster-than-light propulsion systems, long feasible but impractical, will soon power our starships.

Agrarians have the health of the planet well in hand and global competition and conflicts are things of the past. Those are reserved for off-planet issues. The tensions at the Mars settlement remain unresolved. The mining conglomerates face criticism for having taken control of so many asteroids.

Our opportunities, responsibilities, and challenges now extend well beyond our planet, becoming intergalactic.

Some things of course don't change. We remember the global rush of disbelief when what we thought was the "new Apple headquarters" one day lifted off, seamlessly and with total grace, headed towards the heavens, overtaking the SpaceX Tesla on the way towards Pluto. Then we realized that this had been planned all along.

We know there is intelligent life in other parts of the galaxy. But they may be avoiding us, since we're still not evolved enough to be of much consequence.

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*Simone Ross is co-founder & chief program officer of Technomy. Glenda Cudaback is our ace program consultant.*







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# GENOMIC MEDICINE IS HERE. AMERICAN HEALTHCARE ISN'T READY.

Will traditional healthcare get out of the way?  
Institutions aren't prepared and doctors are resistant, even though new tools  
can make Americans healthier. **BY MEREDITH SALISBURY**

■ BY SOME ESTIMATES, as many as half a million people have had their genomes sequenced—through research projects, clinical programs, or consumer services. In the next few years, that number is expected to grow quickly into the millions. This data has already contributed to major medical success stories, but it is not yet clear that genomics can overcome the significant barriers that exist in traditional medicine to achieve its potential for healthcare.

When genomic medicine works, it works impressively, helping doctors diagnose rare or novel diseases and successfully treat patients, sometimes with drugs approved for other conditions. It can provide more accurate prognoses for things like cancer recurrence or susceptibility. But it's

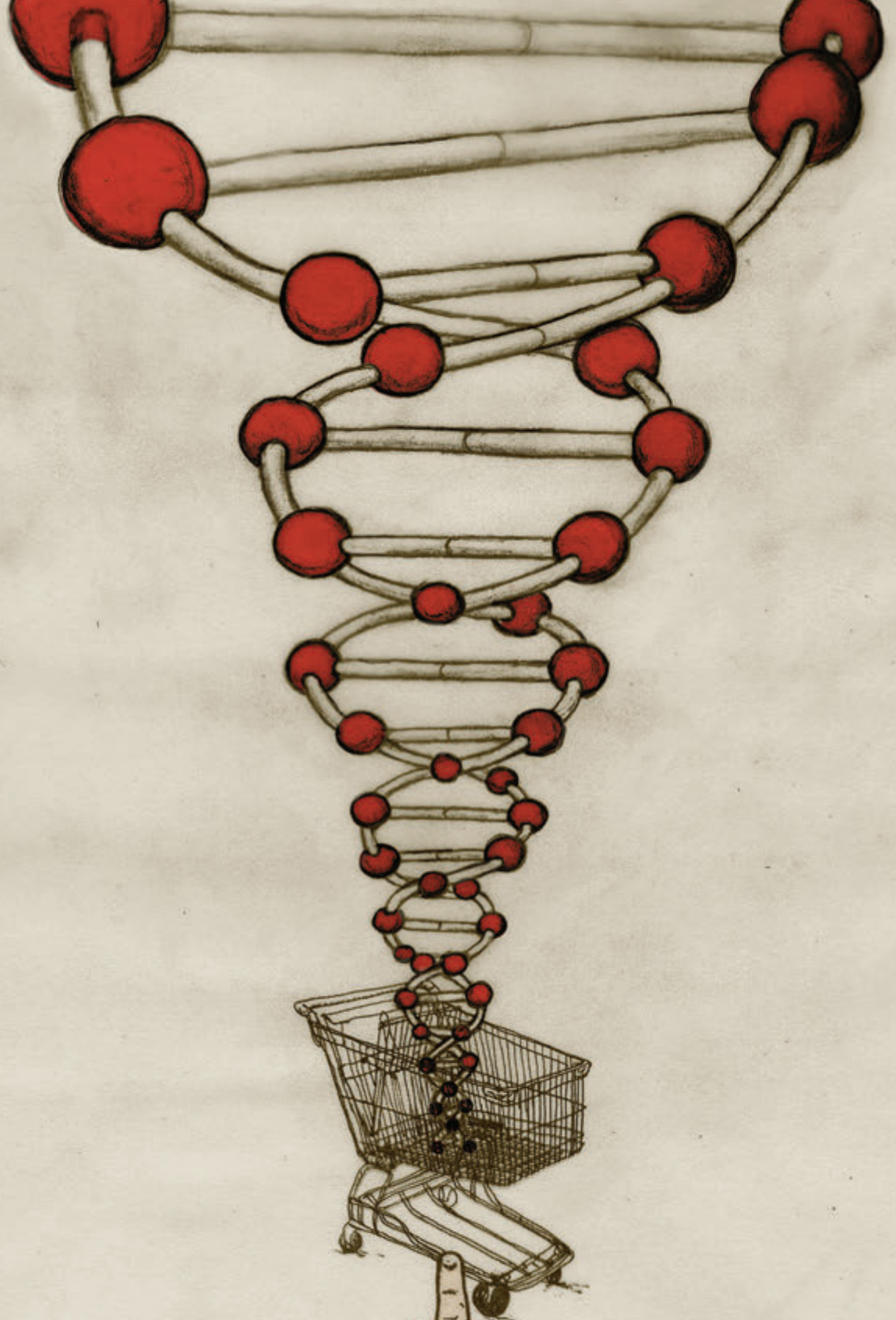
an entirely new form of information, and one that doesn't fit neatly into medicine as we know it. There are several big systemic challenges that need to be addressed before genomic medicine can make a difference for the average patient. That includes electronic medical records that aren't structured to hold DNA information, and physicians who have insufficient training in genetics.

One major promise of genomic medicine is that it could give consumers far more control over their own health. A person who learns that he or she is at significantly increased risk of developing Type 2 Diabetes or of becoming obese, for example, has more motivation to change his or her diet and lifestyle. But consumers need help incorporating genetic

data into their lives, from better basic education to increased availability of genetic counselors.

Despite the challenges, genomics experts are optimistic. According to George Church, a genomics pioneer, professor at Harvard, and founder of the Personal Genome Project, "We're at a tipping point" with genomics, where "you actually believe it could do something for you the way you believe your cell phone and your car can do something for you." He continues: "The instant that word starts spreading...it will be very interesting to watch."

■ T'S NO SECRET that most physicians are apprehensive about genomic data. Extensive surveys in the field, as well as anecdotal data from hordes of patients, reveal that



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doctors are resistant to this kind of information—sometimes because they believe it holds no medical value, but more often because they are not confident in their ability to interpret genetic data and make treatment or other decisions based on it. Electronic medical record systems were not built to hold this kind of information, making it even harder to integrate into routine clinical use.

“Physicians don’t want to be surprised; they don’t want to look stupid,” Church says. “So they will push back. And if they genuinely don’t feel that it’s the standard of care—which it isn’t—they may be justified.” (“Standard of care” means the conventional approach to treating a particular disease or situation. Doctors are inclined to stick to it to reduce liability risks and increase their chances of getting reimbursed by insurance companies.) Church believes society will overcome this impedance quickly, as consumers spread the word about which doctors embrace genetic testing, just as they share their views about doctors in online rankings now.

There are signs of progress. A massive genomics effort at Geisinger Health System in Pennsylvania aims to generate DNA data on 250,000 people. The project required an entirely new approach to working with patients, including new consent forms to cover genomic information, figuring out how to handle unexpected findings of important medical data, new sorts of links to patients’ medical records, and more. This is a massive investment for Geisinger, but as projects like this one work out the kinks, they could provide a template for other healthcare institutions that don’t



**IF YOUR LAST ENCOUNTER WITH GENETICS WAS IN HIGH SCHOOL BIOLOGY, YOU’RE PROBABLY WOEFULLY UNPREPARED TO TAKE ADVANTAGE OF DNA DATA.**

have the resources to start such programs from scratch.

Getting physicians on board will take time. Medical schools today are doing more to implement education around genome sequencing, so newly minted MDs from now on are likely to have open minds about using this kind of data.

Steven Murphy, a physician and managing partner of the Diagnostic and Medical Specialists of Greenwich in Connecticut, has carefully built genomic medicine into his practice. He believes that reimbursement policies and clinical labs will play important roles in the transition. “If labs can make quite a bit of money, they will make sure that doctors order the tests,” he says, noting that educational programs and community support are two common methods used by labs to promote new sorts of tests. “Right now genomic medicine is nowhere near the standard of care in many fields, and is the standard of care in very few fields,” Murphy adds. “I believe that in the next five years, that will reverse itself.”

Genome interpretation services will also be critical. Genome sequencing routinely reveals millions of genetic variants in each person’s genome, including hundreds of thousands that may be unique to each individual. Even the most motivated physician couldn’t hope to be an expert on all of those variants, so data analysts around the world are working to build automated interpretation systems that could provide useful guidance about their importance and what biological impact they might have.

As doctors and medical institutions brace for the onslaught of genomic data, consumers have plenty to do as well. If your last encounter

with genetics was in high school biology class, you’re not alone—but you’re probably also woefully underprepared to take advantage of DNA data that could help you lead a healthier life.

Initiatives like the Personal Genetics Education Project at Harvard are making strides in getting consumers ready for this kind of information, with efforts aimed at young students, teachers, Congressional representatives, and even Hollywood writers and producers. (It assists them in realistically portraying genetics-related topics.) Biologist Ting Wu, founder and director of the project, says that when her team goes to classrooms, their main objective is just to foster an interest in DNA. “Our top goal is to convey a sense of confidence that genetics is accessible to anybody; that their opinions, even if they’re not scientists, matter and are valid,” she says.

Whether consumers get genomic information on their own or through a doctor, the best tool for figuring out its relevance is a genetic counselor. These are the relatively scarce medical professionals who are trained to interpret genetic data and to help people understand what they could learn, what they won’t learn, and how to use the results they get. Today there is a severe shortage of such counselors. That will become a major obstacle to proper use of this information as more people gain access.

**E**VEN AS EFFORTS are underway to integrate genomic medicine with routine health-care, attention must be paid to the substantial looming ethical questions. Genetic testing has gained traction fastest in prenatal care, where

it is quickly displacing conventional screening tests for fetal disorders. As these tests shift from looking at a few genes to a baby’s whole genome, we may learn more than we bargained for. Parents may face extremely hard choices about terminating pregnancies. Doctors will struggle with what information parents should get access to. And ultimately society will have to debate how much it values biological diversity versus specific goals of altered health, athleticism, intellect, and more.

We also owe ourselves a serious debate about our right not to know things. Should people be able to opt out of receiving results for their susceptibility for, say, Alzheimer’s disease? Conversely, will there be a point at which the societal need to allocate resources for taking care of a growing population with Alzheimer’s will outweigh an individual’s right to blissful ignorance?

Esther Dyson, a philanthropist and board member of the Personal Genome Project, contends, “It is your data. It is your right to look at it, understand it, share it—or not share it.” But she thinks concerns over people’s reaction to genetic results are overblown. “I think more people commit suicide or have heart attacks over their tax forms than over genetics,” she says.

For his part, Church sees the imminent public acceptance of genomics as game-changing. “Every now and then, consumers embrace very complicated technology,” he says. “It breaks through the priesthood that can build up around really old technologies. Probably the most important feature of genomics is that it’s new.”

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*Meredith Salisbury is a longtime journalist about genomics and a communications consultant in life sciences. She co-founded the Consumer Genetics Conference.*



Terrence Sejnowski, Salk Institute for Biological Studies: “One of the biggest applications of machine learning is going to be in analyzing large data sets, **RECORDINGS FROM THE BRAIN...** There’ll be a neural technology industry that grows out of the Brain Initiative as important as the biotech industries that grew out of the war on cancer.”

Juan Enriquez, Co-Author, ‘Evolving Ourselves’: **“WE’RE RUNNING AN ABSOLUTELY GIGANTIC EXPERIMENT** on life on this planet. We have to dare to recognize that we are increasingly in charge of the evolution of bacteria, of plants, of animals, and ourselves.”



Marc Benioff, CEO, Salesforce: “Pretty soon **INFORMATION SCIENTISTS ARE THE ONES WHO WILL START TO HAVE THE BIG BREAKTHROUGHS** on the biological sciences...Our government needs to step it way up on NIH and NSF funding.”

Ellen Jorgenson, founder, Genspace: “We hear it all the time: ‘I’d never eat a genetically modified tomato. There’s **DNA in it.**’”

Erika Check Hayden of University of California, Santa Cruz: “The data shows that **most Americans don’t actually know** what GMO means.”

# “IF YOU HAD TO INVEST IN JUST ONE TECHNOLOGY, WHAT WOULD IT BE?”

Four life science experts answered that question on a panel called “Sitting on a Can of Miracles,” a phrase investor Steve Jurvetson used at TE Bio last year to describe biotech’s potential.

■ New York biotech consultant Nancy Kelley: “**Engineering biology.** It’s going to introduce solutions to many of the global problems we’re facing in agriculture, energy, health, and environment.”

■ Greg Simon, CEO of Poliwoog: “**Neuroscience,** because if we don’t solve the Alzheimer’s problem, every hospital in the country is going to be filled in 20 years.”

■ Amy DuRoss of GE Ventures: “**Autologous cell and gene therapy,** because...it’s curative. Like T cell therapy—you take a person’s own cell and reprogram it to then go back inside the patient’s own body and attack tumors or tumor cells.”

■ Ryan Bethencourt of Indie.bio: “**Vascularization**—the ability to grow capillaries and blood vessels within tissue. This is one of the biggest stumbling blocks for organogenesis, or printing and creating new organs.”



■ Linda Avey, co-founder, 23andMe: “People want to **learn about themselves,** and they should have the right to do that.”

## Synthesizing Techonomy Bio

We spent a day in March in Mountain View discussing how digital tech puts life sciences innovation on a stunning trajectory. Here are some of the ideas that flew fast and furious. We walked away stunned with the panoply of possibilities.

### A comment about growing cellphones prompted responses all day.



a liquid that has copper in it. It will actually assimilate that copper into its cellular network and act as a conductor...a circuit. So I think the potential to grow a cell phone is real.”

■ Stanford Genomics expert Drew Endy: “Within two to three decades I think I can grow this [holds up a cell phone]. We got really good at engineering systems that handle bits, and now we’re going to get really good at engineering systems that handle atoms.”

designed, controlled, sculpted, and architected world where things do what you want, to a grown, organic, robust future where the physical artifacts are grown and for the software the metaphor might be closer to parenting than engineering.”

*During a later panel:*

■ Investor Steve Jurvetson of DFJ: “What he said is a metaphor for the future—moving from a manufacturing,

Joe Tarantino, fermentation biologist, Ecovative: “We’ve done research at Ecovative to grow fungus in

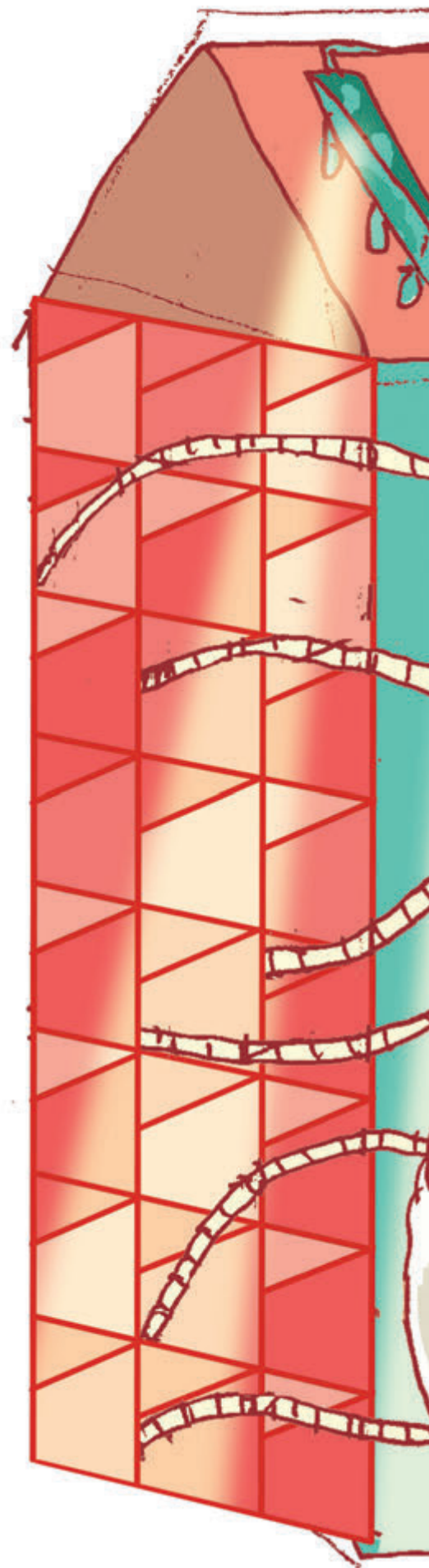
■ Ginger Dosier, CEO, bioMASON: “We’re growing bricks, using trillions of tiny workers, bacteria that create a calcium carbonate cement. The process starts with sand. And then it gets inoculated with the organism. It’s literally fed for two days, until a solid brick is formed...At least 1.2 trillion bricks are fired every year. That makes 800 million tons of CO<sub>2</sub>, more pollution than all the airplanes in the world combined.”

# WILL PROGRAMMING PLANTS FEED THE WORLD?

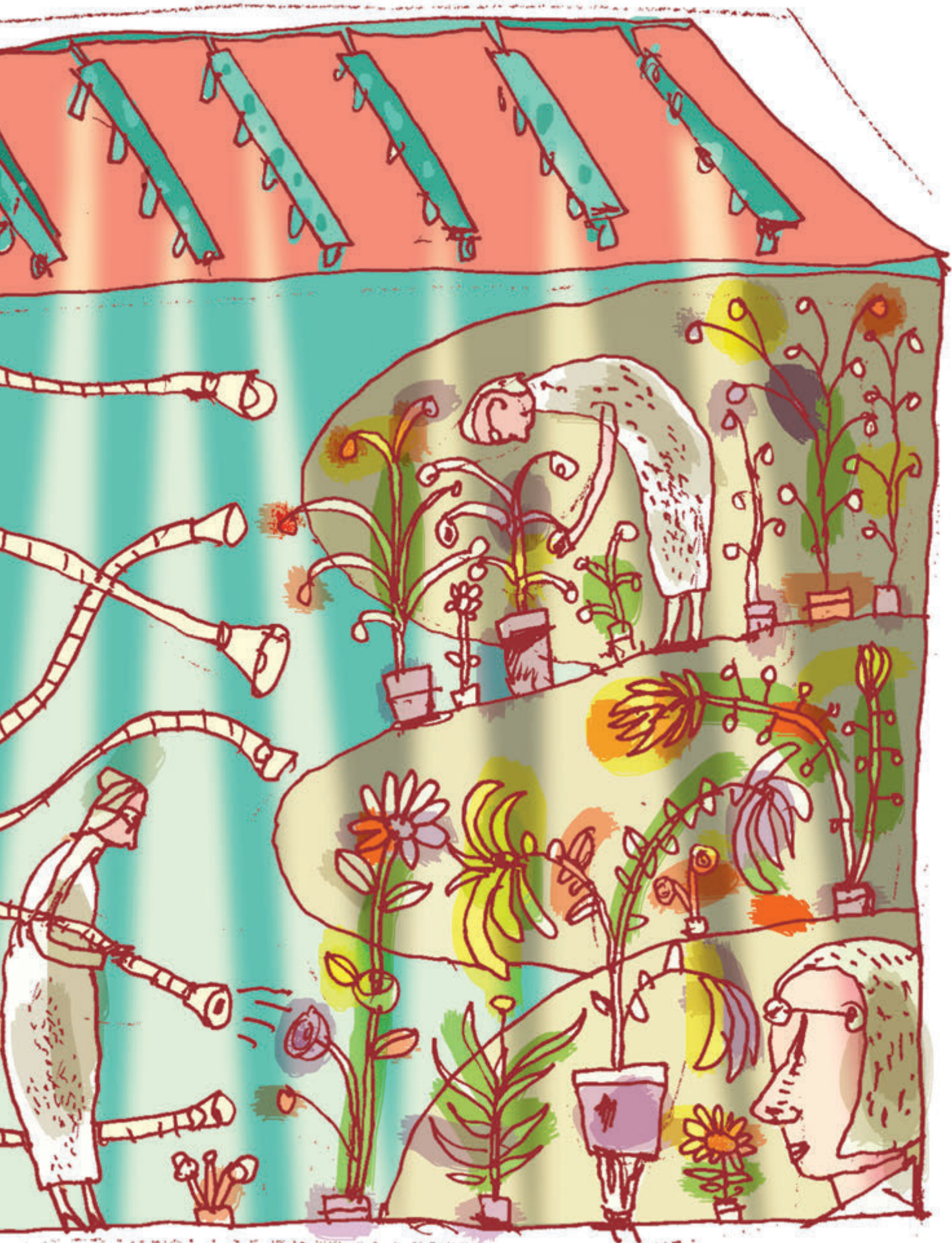
BY DAVID KIRKPATRICK

**I**N A LITTLE NOTICED ANALYSIS PUBLISHED IN 2014, data giant Thomson Reuters announced that by 2025, food shortages and price fluctuations would be a thing of the past, everywhere. But how could that be? What about overpopulation, climate change, radical shifts in rainfall, global water shortages, disappearing Himalayan glaciers drying out farmers' fields in India, and all the other dire predictions of food scarcity and disorder we've heard in recent years? The data firm dismissed it all, projecting that new technologies for cultivating plants would expand food production, "helping feed the world's eight billion people and overcoming environmental changes that will affect traditional farming." The analysis continued: "In 2025, genetically modified crops will be grown rapidly and safely indoors, with round-the-clock light, using low-energy LEDs that emit specific wavelengths to enhance growth."

Thomson Reuters came to its conclusion by dweeby means—applying data science to its gigantic collection of patent filings and scientific papers and extracting a previously undetected pattern. But a growing army of food scientists, businesspeople, and techno-farmers are already starting to live out the prediction. Eri Hayashi is a feet-on-the-ground Japanese researcher who has spent the last three years visiting and evaluating actual indoor farms







around the world. It took her a while to become convinced, she says, “But I really do now believe we are heading into a new era in food production.” Here’s another indicator: companies already poking around this field include Amazon, Starbucks, Kellogg, Target, and many of the world’s largest food-producing corporations.

This startling new form of technologized agriculture goes by different names in different places. In Japan, where it is by far the most advanced, over 150 so-called “plant factories” operate already, reports Hayashi. Taiwan comes next, with about 30, she calculates. In the U.S., there are probably about 70 “vertical farms,” but only about 10 of substantial size, she says. But they

include the world’s largest single installation, Green Sense Farms, which commercially grows arugula, cilantro, kale, lettuce, and peas in Portage, Indiana near Chicago. Dickson Despommier, an emeritus professor of public health and microbiology at Columbia, helped prod growth in the U.S. —and name the industry—with his 2011 book *The Vertical Farm: Feeding the World in the 21st Century*. In Europe, where activity is widespread, the phenomenon is known as “city farms.” Meanwhile, several experts told Techonomy that China will soon dominate. Its government is quietly building at least three “agricultural parks”—massive indoor growing fields. China’s serial food-quality crises have made safety and purity a paramount concern for

consumers, and indoor farms offer unprecedented quality control and predictability.

The field is blossoming, even as most people still haven’t wrapped their heads around the idea that their salad might come from a dark room lit like a nightclub. Most American vertical farms are quite new. “It will be a trillion-dollar industry in 20 years,” Despommier says. “By then virtually every city in the world will have vertical farms.” Singapore is moving so fast—with government support and four companies already operating—that he expects in five years the city-state, which has little room to grow conventionally, will produce 30% of its “consumable vegetable material” indoors.

Whatever you call it, an indoor



farm is an incongruous and unfamiliar site—typically a vast warehouse-like space with stacks of as many as twelve illuminated beds filled with rapidly-growing plants under rows of mostly red and blue lights. Nutrient-rich water passes in trays beneath each row. The atmosphere resembles a clean room in a chip factory. The “farmers” are white-coated technicians, adjusting the environment and maintaining electrical and digital systems that regulate growth. Some farms even have automated conveyors that periodically move seedlings to bigger



beds, replanting and respacing them under slightly different lights. Says Chris Higgins, general manager at Hort Americas, a supplier of indoor agriculture supplies near Fort Worth and publisher of the online *Urban Ag News*: “In controlled environment agriculture [the name he prefers] it can be like Groundhog Day—an environment where every day is the same day. The goal is to have as much control over the variables as possible.”

AeroFarms is building its indoor farm in the soaring steel bones of an old factory in a grungy urban neighborhood in Newark, New Jersey. When completed, it will be even bigger than Green Sense. AeroFarms recently raised tens of millions from Goldman Sachs, among other investors. The company in fall 2015 began

shipping produce from a smaller facility to ShopRite Supermarkets after years of planning and development, and will soon start supplying Whole Foods and other customers. “This is engineering meets horticulture meets data science,” says CEO David Rosenberg. “These are MIT-trained coders who understand how to take data and optimize not just yield but taste, texture, and nutritional density. We have mechanical engineers, structural engineers, lighting engineers, and process engineers.”

Produce grown under such conditions typically matures faster, has more leaves, is crisper, tastes better, and stays fresh considerably longer than field-raised plants. It can be produced year-round and the amount of water used is as little as 2% of what would be necessary outdoors.

We desperately need new ways to grow our food. As the global middle class burgeons, the world must produce 70% more calories and at least 100% more total agricultural crops by 2050, calculates McKinsey. Meanwhile, the newly-announced Sustainable Development Goals endorsed by the United Nations dauntingly call for a complete end to “global food insecurity” by 2030. Economist Jeffrey Sachs, the goals’ biggest apostle, recently said that agriculture “is still the number one driver of climate change and global pollution.” McKinsey says agriculture is today a \$5 trillion industry—the world’s largest—and represents 10% of global consumer spending, 40% of employment, and 30% of greenhouse gas emissions (though methane from livestock creates a considerable portion).

There is no way to produce the increasing amount of food we will need without massive improvements in growing technology. Happily, conventional farming has already made



■ **Packaged greens (top) grown indoors in Japan; A plant factory (above) in Osaka, Japan; At left: Philips’ GrowWise Centre in Eindhoven, Netherlands, where it tests special LEDs for indoor plant cultivation**



immense strides outdoors. Yields for greens grown in California, for example, are up as much as ten times since the early 1990's. One reason is that farmers are using data to understand the exact combination of water, sunlight and fertilizer that will make plants that will thrive in their fields. "A farmer growing cilantro may have his own catalog of 300 different varieties of seed for his property," says Higgins of *Urban Ag News*. "One variety may do better in the front of the property and another in the back." But the next step is to take all this control to another level. Indoor plant cultivation under lights has been around for decades, but doing it profitably at scale proved elusive.

Now, however, the technology is improving rapidly. The breakthrough came with LEDs, or light-emitting diodes, a technology more closely related to semiconductors than to traditional incandescent lights that heat up a filament. LEDs can be tuned in myriad ways for the red and blue light that is most important in photosynthesis. Philips, based in Eindhoven, Netherlands, has become the world leader in agriculture lighting. Cees Bijl oversees emerging businesses including what Philips calls Horticultural LED Solutions. "The critical thing we did seven or eight years ago," he explains, "was to say we don't want to just supply a light to the grower, but to supply the whole solution, including the light recipe. We now have LEDs emitting wavelengths for specific crops." The efficiency of LEDs has also dramatically improved. Reports Robert Spivock, engineering leader for General Electric's Specialty Lighting division: "Back in 2005 a blue LED was giving in the range of 30 lumens per watt. Now off the shelf it can generate up to 130 lumens per watt. So the amount of light pro-

duced compared to what's lost in heat has increased tremendously. You can bring the light down close to the plant without burning it."

The advances in LEDs dovetail with rapid improvements in hydroponic systems for growing plants in water (driven in part by the fast-growing cannabis industry), as well as software for data analytics and systems control. Indoor farmers can now measure, store, and control the full range of variables that affect the rate of growth, size, and characteristics of a plant—not just lighting color and intensity but nutrients, humidity, temperature, and carbon dioxide concentrations, among many factors. But the reality is that we are only beginning to understand how all these variables affect specific plants.

Caleb Harper, an architect by training, runs the Open Agriculture initiative at MIT's Media Lab, supported by companies like Target and Hong Kong-based food company Lee Kum Kee. Harper has become perhaps the most vocal and visible cheerleader for a wholistic approach to controlled agriculture which might be called "programming plants." He sees plants as a sort of artist's palette—a set of capabilities that can be employed in an infinite variety of ways.

It's easy to get him talking about the opportunities: "When somebody says 'Oh the Bordeaux from 1965 was the best! Blah blah blah,' what they're really saying is just that the climate that year produced the expression that we like. If we can curate climate, we can create the best climates we know, like the one that produced that Bordeaux that year. But it also means we can experiment with climates that don't naturally occur. We can use capabilities that are already in the seeds. We don't even know what the combination of environmental

variables does to produce a specific expression in a plant."

Chris Higgins of *Urban Ag News* agrees. "We may be able to start to reconstruct what plants look like, without going to GMO, which is a word everybody hates." He says, for instance, that while wheat is one crop that can't easily be grown indoors, maybe it could be if we could induce wheat to grow 6 inches tall. Higgins explains that the plants we eat today invariably have already undergone dramatic modification through selective breeding and hybridization over a long time. "You wouldn't have enjoyed a kale salad 50 years ago," he says. "We've continually selected out traits that make it more attractive and edible."

"There's no understanding of basic biology," continues MIT's Harper. "Genomics and gene physics is not what I do. Instead I work with the phenome, which expresses the gene. That just means 'phenomena.' You're programming the climate, and that in turn programs the food. You're programming the phenome to create the crop-based expression that you want."

One thing that matters deeply to Harper, though, is that the phenomic "programs" for growing useful new varieties of plants be widely available. He is distressed by the secrecy that characterizes much of the indoor agriculture world, saying it undermines cooperation that could more rapidly achieve the advances the world needs. He wants to "open source" indoor agriculture technology. This is why he calls it the "Open" Agriculture initiative. One of his newest partners is Mitchell Baker, longtime president of the Mozilla Foundation, creators of the open source Firefox browser. Baker will work on an intellectual proper-



ty framework that may enable food researchers to more readily build on one another's innovations.

To promote the field, educate kids, and help develop "programs" for specific plant variants, Harper has recruited teachers from six junior high schools and high schools in the Boston area. Each classroom now has what Harper calls a "personal food computer," a TV-sized enclosed growing environment, like a mini version of the larger factory systems. "Inside the boxes we're creating climates, and the climate then becomes digital," says Harper. "A seventh-grade class can drag a climate onto a desktop." And then it can be shared. He's confident soon such micro-farms will be widely available. Many of us could then become experimenters, unlocking new potential foods and functions from plants. And you thought 3D printing was cool!

Another challenge for the indoor farming movement is the question of whether its products are "natural" or "organic," or whether it even matters. A few certifying authorities

■ **The Open Agriculture initiative at MIT placed the Personal Food Computer in this classroom and five others in the Boston area. Students create "recipes" for growing plants with specific characteristics.**

have begun to accept indoor greens as organic if the nutrients in the water are organic, but most still insist on outdoor fields and real dirt. Biologist and vertical farm advocate Despommier of Columbia has little patience with such thinking: "If people say the only way to grow naturally is to use dirt, you have to tell them farming is not natural, period. You have to destroy ecosystems in order to farm. And we can't afford that because that's our life support system. So we have to restore our life support and have food. The way to do that is to get off the land. Leave nature alone, and it will repair itself."

The persuasive environmental arguments for indoor agriculture could turn out to be the biggest factor in helping Thomson Reuters' predictions come true. Despommier calcu-

lates that if every city on earth were to grow 10% of its produce indoors, it would allow us to take 340,000 square miles of farmland back to forest. That, in turn, could absorb enough carbon dioxide to bring the level in earth's atmosphere back to where it was in 1980, he says. The water savings in indoor farming offer numerous other major environmental benefits. One is to reduce water pollution caused by agricultural runoff, one of the world's great scourges.

Then there's the satisfaction of having fresher, tastier food grown nearby, perhaps even by people you know. Artesian Farms in Detroit is already getting traction locally with its "Motown Mix" of salad greens. Corner Stalk Farm grows in five converted shipping containers in a parking lot in East Boston. Says Lisa Lillelund, a Boston-based serial entrepreneur who is starting her own indoor-farming business: "This is allowing clean tech to support the local food movement. What a wonderful marriage."

Now entrepreneurs are planting seeds of all sorts across the landscape. They range from Grove, which sells refrigerator-sized growing environments meant to go in a consumer's kitchen (and which presented at Techonomy 2014), to companies like AeroFarms and Green Sense Farms, which don't just grow food at scale but also seek to license their technologies so others can do the same. (Green Sense already is helping build a facility in Shenzhen, China.) Corner Stalk's parking lot "farm" was also produced in Boston, by Freight Farms, one of several companies that sells complete self-contained containerized systems. After a few days of training you plug in, connect a hose, insert seeds, and go.

*David Kirkpatrick is the founder of Techonomy*

The background of the entire page is a photograph of a densely packed shantytown built on a steep hillside. The buildings are multi-story and constructed from various materials, with many walls painted in bright colors like blue, yellow, and red. In the background, a large, hazy mountain range is visible under a clear sky.

# COULD THE BLOCKCHAIN EMPOWER THE POOR AND UNLOCK GLOBAL GROWTH?



## A radical new form of networked recordkeeping could finally give the world's disenfranchised a record of what they own.

**BY MICHAEL CASEY**

■ HERNANDO DE SOTO, the Peruvian economist and anti-poverty campaigner, estimates that five billion people live without adequate records. They face serious challenges in documenting their economic activities, their assets, even their existence. This documentation failure denies them bank accounts, prevents them from borrowing against the homes they own, blocks them from access to insurance, and greatly weakens their bargaining position vis-à-vis anyone whose life, property, and business activities are legally documented. It's a tragic global economic failure.

Until now, de Soto has depended on political persuasion to try to address this problem, tapping a contact list of world leaders that reads like a U.N. General Assembly roll call. But now he's getting help from new technologies that could fast-track the creation of permanent registries and give people manifest power to

**Economist Hernando de Soto believes the blockchain can allow disenfranchised people worldwide, like residents of this favela in Lima, Peru, to gain legal title to their homes.**

execute their property rights. One of the most promising solutions arises from open-source software called the blockchain that underlies digital currencies such as Bitcoin.

To de Soto, who recently engaged leftist French economist Thomas Piketty in a high-profile debate on such matters, the poor don't lack capital; it's that they can't monetize it. Fixing that, he says, is "the most important thing you could ever do to foster economic growth."

Moving these people from the "informal economy" into the "formal economy," when it has happened, has been an arduous undertaking. It entails the door-to-door drudgery of surveying and proving people's property and identity, a challenge for governments that are often constrained by limited budgets and outdated systems. If the information is processed, it typically then resides in paper records that are prone to loss, disorder, and disintegration. And if it's digitized, it's in proprietary databases with formats that typically can't interact with each other. All this makes it very hard to keep track of changes, such as the liens that creditors attach to property deeds. Such inefficiencies create such astronomical financial burdens that already-marginalized people and businesses frequently just opt out of the formal economy altogether.

The blockchain offers a potential alternative. The independent computers that run Bitcoin's decentralized network busily update and maintain an ever-growing public ledger of transactions. They repeatedly reach a consensus on changes and thus are constantly vouching for the ledger's integrity. Information on new transactions is built on top of all preceding records in a precise, time-stamped, interlinked manner, which means anyone who tampers with past data will distort all other latter records and so expose their fraud. It is this permanence and incorruptability,

combined with the fact that it is completely open and uncontrolled, that makes this new recordkeeping methodology so seductive. And the distributed nature of the blockchain ledger, which resides simultaneously on multiple computers, makes it far more secure than a centralized database. All these features make it possible for individuals to confidently and securely use the blockchain to make direct asset exchanges without relying on third-party intermediaries such as banks, lawyers, or notaries.

While the technology was first developed for peer-to-peer currency transactions, innovators are now seeking to use the blockchain—either the Bitcoin blockchain or competing versions of it—for many other applications, including on claims to property title. Inserting metadata (data about the data) into blockchain-based transactions can create a robust, reliable record of all sorts of changing information. At the MIT Media Lab's Digital Currency Initiative, where I work, we are exploring some of these uses for projects with social impact like the one championed by de Soto. And this exact application is being actively explored by the government of Honduras. It is working with Austin, Texas-based startup Factom to understand how it might use blockchain technology for land registration.

The blockchain isn't a magic bullet for the developing world. The technology is unproven and Bitcoin's version of it faces scalability limits, among other challenges. Meanwhile, citizens still need government authorities to authenticate the input data on their claims to houses, cars, or personal identities. In slums, where criminal gangs often dictate who has rights to each piece of property, get-

**Hernando de Soto with Peruvian miners and their families. (They don't mine Bitcoin, but he thinks the blockchain can help them.)**



ting accurate and fair information poses an additional challenge. Still, once it's created, the presence of an immutable blockchain ledger could help boost people's confidence in public records.

Financial institutions will be more willing to provide services if they can trust the data, de Soto says. Just as important, ordinary people might overcome their reluctance to cooperate with data-collecting authorities.

"The reason people don't go around recording themselves, besides the fact that record-keeping systems in former Soviet and developing world countries are shabby, is because when they give over that information, they don't trust who they are giving it to," de Soto said during a recent visit to New York. "They don't want to be vulnerable to some-





thing that can be used against them. And that's what's interesting about the tamper-proof blockchain – if you can get the right message about it out there, [people will see] that it's worthwhile recording yourself.”

In “The Mystery of Capital,” his bestselling book from 2000, the Peruvian economist argued that the absence of formal title to property meant there was \$10 trillion in “dead capital” in the world economy—a tally of all the houses, small business assets and other property for which there are owners but no formal documentation. His Lima-based Institute for Liberty and Democracy has since updated its calculations to account for the foregone gains that people and businesses in the informal sector surrender to their counterparties in the formal economy. De Soto now

puts the total figure at \$20 trillion.

If you unlock that dead capital, “there are no reasons why you don't end up with Chinese or Indian growth rates worldwide,” de Soto said with enthusiasm. “What happens to these economies if now there is trust?”

Dramatically more rapid global growth of 8 percent-plus is possible, de Soto contends, because such changes in recordkeeping would dramatically free up the potential for transactions, which are the essence of economic activity. “For these people, making transactions is the most costly thing you've ever seen,” he said. “The time it takes to record the existence of a building can be from one year to 20 years. So if the processing time for recording can be reduced, quite simply transactions

will increase.”

De Soto has been banging this drum for decades, and while he has won many over to his cause, the task remains incredibly daunting. But with China's economy slowing, commodity prices plunging, and an air of crisis in emerging markets, “this is exactly the moment to do this,” he now says. Add to that the blockchain, and this relentless campaigner for the property rights of the poor senses opportunity: “All kinds of movements have happened at times like this.”

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*Michael Casey is senior adviser for blockchain opportunities for the Digital Currency Initiative at the MIT Media Lab. He co-authored (with Paul Vigna) The Age of Cryptocurrency: How Bitcoin and Digital Money Are Challenging the Global Economic Order, published by St. Martins in January 2015.*



This page (clockwise from top): Femto-manager Michael Fertik (also executive chairman of Reputation.com); Panel, from left: Infosys co-founder Nandan Nilekani, Twitter and Square’s Jack Dorsey, the International Rescue Committee’s David Miliband, Genevieve Bell of Intel; Techonomy’s David Kirkpatrick with Reid Hoffman and Peter Thiel; Scientist and author Jaron Lanier; Journalist Barton Gellman; (above) Bloomberg TV’s Emily Chang with David Marcus of Facebook Messenger



Photographs by Steve Kepple (6), Cynthia Wood (5)

## IDEAS FLEW FAST AT TECHONOMY 2014

Our annual conference in Half Moon Bay, California is our ultimate curation of people with ideas.



This page (clockwise from top left): the New York Times' John Markoff with (from left) Steve Jurvetson of DFJ, FCC Commissioner Jessica Rosenworcel, and Ford CTO Ken Washington; (from left) Simulmedia's Dave Morgan, Techonomy's Simone Ross, LOVELAND Technologies' Jerry Paffendorf; (from left) Bonolo Matjila of Spiruteens, Leroy Mwasaru of Human Waste Bioreactor, and David Sengeh of Global Minimum; The New Yorker's James Surowiecki asks a question from the floor; Dinner under the tent

# “WITHOUT DESIGN, INNOVATION DOESN'T HAPPEN.”

A  
conversation with  
Paola Antonelli,  
senior curator of  
architecture &  
design and director  
of R&D at The  
Museum of  
Modern Art

**Interviewed by  
David Kirkpatrick**

**Antonelli in  
the Museum of  
Modern Art's  
galleries.**



*Paola Antonelli is a passionate advocate for the importance of design in society and business. She worked as an architect and a design journalist in her native Italy before joining MoMA in 1994. Among many noteworthy shows she has curated there are Safe: Design Takes on Risk (2005), Design and the Elastic Mind (2008), and Talk to Me: Design and the Communication between People and Objects (2011). She's given three TED talks, written numerous books, and just began a sabbatical from the museum with the intention of writing yet another. Techonomy's David Kirkpatrick interviewed her over lunch in New York.*

### **What is design?**

Generally when people ask me for a definition of design, I change the subject. But one of the things I am hoping for in this sabbatical is to come up with a sort of “theory of everything” for design. When I speak of design, I deal with every endeavor that entails a creative process and has a goal. The goal may be speculative, for instance to design a scenario for the future. It can be a visualization, a diagram; it can be a chair; it can be an interface; it can be bio-design, like the form of an *in vitro* steak—anything you want.

Also, the final outcome of the process needs to involve at least one of the senses. So I usually don't consider what's often called “design thinking” to be a form of design. But I consider infrastructure to be, because it deals with our whole individual and societal body. What's important to me is the connection of design to the world. It moves me when I see designers really trying to make things better.

### **Why do you want to help people reconceive what design is?**

I want them to reconceive what an object is. People don't realize that

design is truly all around us, not only in things, but also in interfaces and in the way streets intersect. Sometimes it's good. Sometimes it's bad. But it's made for us. We are the critics, ultimately. I try to expose people to as much design as possible, of as many types as possible, and help them sharpen their own critical tools. I would like people to be more aware of the choices that are made for them. There are design features you should learn about—for instance an object should be designed so that components can be separated at the end of its life. Perhaps you will choose to buy only products that can be upcycled and recycled.

There are impeccable design objects, and some are clearly bad. But there are many nuances. I want people to know that they have to think not only of the form, the function, and the price, but also of how the object was manufactured, where it was made, who was behind it, how it's going to die, where it's going to be used, and where it's going to end. The story behind objects is as fascinating as a movie.

### **How did you arrive at your own reconception of these bound-**

### **aries for what's thought of as design?**

Some people think design was born after the industrial revolution. Other people think it was born after Raymond Loewy's stance as “the first professional designer.” As far as I'm concerned, it was born when we started making our own tools in the stone age. I keep the definition of design pretty wide.

I went to architecture school. And in Italy at that time, it was highly theoretical. When you emerged, you could become an architect, but not necessarily. You could become a graphic designer, or a furniture designer. Fashion designer Gianfranco Ferré was an architect. You could become a chef. When taught in this philosophical, abstract way, design is a universal donor to any field that is about making and constructing, whether in the digital world or in the physical world.

But the amplitude of my viewpoint about design became particularly urgent when I came to New York twenty one years ago, and I realized that the American public thought of design as cute chairs, commercial products, and fast cars.

I started out with an exhibition called *Mutant Materials in Contemporary Design*, in 1995. That was an attempt to show that even materials can be concocted by designers, and that a shift in the technology of materials had put more power in their hands. In the past, in order to produce a plastic chair a designer had to work with engineers, and a manufacturer had to make a hefty investment to make injection molds in steel or aluminum. But by 1995,

resins were available that could cure at ambient temperature, in fiberglass molds, and composites could be shaped by hand by the designers themselves. So the control of materials was no longer only in the hands of big chemical engineering companies.

That was also when we started the MoMA website, in 1995. I learned HTML and I coded the website. Nobody really knew what a website was, so nobody knew who was supposed to sign off—Publications? Marketing? Communications? They gave me a budget of \$300 that I used to take taxis to the School of Visual Arts, where a graduate student taught me HTML.

### Who are you trying to curate for?

I want to disseminate design to as wide an audience as possible. I studied architecture in a polytechnic, so I've always been very comfortable with technology. (I worked as an architect for only six months. I really stank.) I deeply believe that design is the highest form of human creative expression. It brings everything together for other human beings—science, engineering, technology, politics, art, economics.

Children are the toughest critics. They have an indifference to platforms and spaces. They don't need to distinguish between digital, physical, or in between. I believe that even scent is a form of design, and children immediately understand when I tell them so. Adults instead form separations and distinctions in their minds. One of the most pernicious is the distinction between design and art. That is one of my pet peeves. Several times artists were dissuaded from participating



The curator's office reflects the disorder of a well-filled mind.

in my shows at MoMA, because their gallerists were afraid that the price of their work would be diminished by appearing in a design exhibition.

### You think that distinction is irrelevant?

It is relevant, but it should not be based on the idea that art is higher than design. Art is certainly more expensive than design, however.

### How should companies think about design? What's missing?

Individual designers that work on individual projects. There are a lot of big and corporate design firms that are great—Ideo, for instance, or frog, or Ammunition. But the big companies are missing masters like Hella Jongerius, the most important furniture designer alive. Her work is not only relevant to decorators and design buffs, but to all people who want to know what human beings are like, today and in the future. She is able to mix old and new, to learn from African crafts and metabolize what she has learned in new products, rather than mimic it as a typical Western designer.

### What do businesses miss by not employing people like that?

I don't think they should employ them. They should dream of employing them. They should know about them, and their culture would improve—and so would their products. But you know what? That's one step beyond. We'll get there. For the moment I'm happy to see that there is widespread interest. The last *Harvard Business Review* was about Design Thinking, grrrrmph. Missed opportunity, but OK, we'll get there, to real design, eventually. One day, business schools will yearn

for design acting. At least they are paying attention.

Once upon a time, Tony Dunne and Fiona Raby used to work with Motorola. They are the two most important critical designers—they build scenarios that speak about the consequences in the future of our choices of today. At Motorola, they were sort of thorns-in-the-side in residence. These kinds of designers do not report to the chief marketing officer or to the head of product. Rather, they probably report to the head of R&D.

Ideally, this kind of understanding of design should be diluted and distilled and absorbed by the company, not immediately implemented and deployed. One place where it is starting to be assimilated is at Google, for instance in the Advanced Technology and Projects team, led by Regina Dugan, who used to head DARPA. Apple also hired some alumni from the Design Interactions program at the Royal College of Art in London, which used to be run by Tony Dunne and is exquisitely speculative.

The world is changing and becoming much more fragmented. Ethnography is becoming necessary for many business decisions. Designers move in that same direction. It would be really great and healthy for companies to just have the curiosity to listen to professionals who come from a completely other creative space.

Without designers and design, innovation doesn't really happen. Revolutions happen in science and business and technology and in politics, but designers are the ones that take these revolutions and make them into life. One of the most classic examples is the Internet. It started as lines of code,

and only a few people could use it. Marc Andreessen and his team designed the Mosaic interface, and all of a sudden his grandmother could push the buttons and use the hyperlinks.

Design takes something revolutionary and makes it usable. Whether they are advocating for human beings, or advocating for earth and sustainability, designers become the interpreters and the synthesizers. Synthesis is one

of the most important functions of design.

**At Techonomy we talk a lot about the urgency of multidisciplinary dialogue. You're saying design, almost by necessity, has to be multidisciplinary.**

The most successful furniture designers of yesteryear, in Italy, knew everything about making. They would spend time in the factory

## Can Design Beget Violence?

**Antonelli:** A few years ago I opened up my eyes and realized that design is not always benign. It all started out with the news about the 3D printed gun. I've always been an advocate of 3D printing and open source. And here comes this guy, Cody Wilson, who uses open source to let everyone have a gun. I remember how stunned I was, and how angry I was that I was stunned. Because I realized that it was so pollyanna-ish of me.

I kept on saying that designers take everything into consideration and I say all these beautiful things about design. But excuse me. In truth design is a double-edged sword. Then I started reading Steven Pinker's book *The Better Angels of our Nature*, which argues that society is becoming less violent. I decided to explore the issue by curating a museum show and I started looking for objects that have an ambiguous relation to violence. My colleague Jamer Hunt and I put together a wonderful exhibition proposal, but it didn't fly. That happens, but this idea seemed too urgent. And so we decided to create a Wordpress site. For one and a half years, ending in May 2015, we published every week a different object that has an ambiguous relationship to design and to violence. Each time, we invited an authoritative and knowledgeable expert to write a small essay. And each time we asked a question to the audience. We called in big favors, so the first writer was Anne-Marie Slaughter; then William Gibson and Steven Pinker himself. People wrote about euthanasia, about female genital mutilation, and about killing animals. The spiral ramp for slaughtering cattle by Temple Grandin had a commentary by Ingrid Newkirk, the president of PETA, and ended with the question "can you really design a violent act to be more humane?" That got more than 100 comments. The last post was about the death penalty, and the writer is Ricky Jackson, a man who was on death row for 34 years before getting completely exonerated.

We finally turned the project into a beautiful book, and the website is still up and as vibrant as ever: <http://designandviolence.moma.org>.



There is such attention to human behavior in Airbnb. [Co-founder] Joe Gebbia several years ago announced to me excitedly that they had decided to change the whole gestalt of the website to talk about neighborhoods, and not just individual apartments. They wanted to position Airbnb as a gateway to communities. That's a very "design" gesture. It's about understanding how people behave. It shows empathy and interest in human beings.

**You've been running a very eclectic and rich series of live conversations at MoMA you call "R&D salons." Why?**

Like many people in the cultural world I have a chip on my shoulder—especially because I did two years of economics school before I came into architecture and design. The product of cultural labor is considered superfluous in society and insignificant for the bottom line of a community. Whenever there's a crisis, politicians slash budgets for culture, and instead they bail out banks. And I'm sorry, but the financial sector is definitely not very human oriented.

When the credit crisis happened in 2008 I thought it could be an opportunity to demonstrate that the financial sector is not really on our side. I proposed to MoMA an R&D department that would prove that museums and cultural institutions are the true R&D of society. The kind of progress they provide is slower, but a good slow, like Slow Food—more reliable, healthier, and more sustainable. We couldn't start the R&D Department at that time because we were dealing with the financial crisis ourselves, so we waited two years, but the program

with the workers. It is about the synthesis, about learning more than might seem necessary. It's never about just designing a shape and letting somebody else deal with it. That's a very reductive and wrong idea about design.

**Beyond her design department responsibilities, Antonelli has been running programs for large groups in the museum's auditorium which she calls "R&D Salons."**

**Airbnb was started by design graduates of RISD. What do you see in the company that's indicative of what you're talking about?**



is now thriving. It is a lot of R and much less D, but it is important.

**Why does that phrase “design thinking” offend you so much?**

It’s become too common. For some, especially in the business and tech world, it is a synonym for “design.” People think they’re talking about design, but they’re not. Design Thinking is to design what the scientific method is to science—the steps without the practice and study. You need to study and practice for years to become a designer, just like you need to study to become a scientist. Putting lots of Post-it notes on the wall is not going to make you a designer.

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*David Kirkpatrick is the founder of Technomy*

## Living in the Mix of Physical and Digital


**Antonelli:** We live in a mixture of physical and digital all the time. Many physical objects have therefore become gateways to networks and to digital universes.

This [pointing to her iphone] is already the integration. If we lose it, it’s a matter of money or security, but it doesn’t change anything. We get another one and have the same access. So the phone is almost a hindrance. People try to make it pleasant and comfortable by improving the interface. We could get rid of it, maybe with a watch. But if we could just have a beauty mark that does it all, I’d be fine.

When I started acquiring video games for MoMA a few years ago and we installed Minecraft, you would see kids dragging their parents to see it. Minecraft is a great example of a design object that connects the physical and the digital. It’s almost like Lego online. It is pixelated and old-school, and at the same time up to date. It creates a community. It’s shareable. It doesn’t get any better. And it is telling in its success over many other high-end games that are perfectly cinematic and impeccable. Sometimes kids do sketches with a pencil before starting online. It’s quite beautiful.

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**“IF WE DON’T KEEP THE INTERNET OPEN AND ACCESSIBLE, WE WILL RUIN AN ENGINE OF INNOVATION AND GDP GROWTH**

which has been substantial over the last 30 years.”

–Google’s Vint Cerf



**“WE HAVE NEVER STARTED THE CONVERSATION ABOUT WHAT RIGHTS IN DATA MEANS.”**

–Brad Burnham of Union Square Ventures

**“TODAY, TECHNOLOGY IS NO LONGER AN ACCEPTABLY FOREIGN LANGUAGE TO SENIOR OFFICIALS IN THE GOVERNMENT.”**

–R. David Edelman, National Economic Council staff, The White House



**“I don’t necessarily want my federal government knowing what I’m eating, and who’s in my house, and when I come and go... And judgments could be made about me in the private sector as well. There have got to be rules. There has got to be A SENSE OF SELF AND THE DIGNITY OF INDIVIDUALS** in this always on, always connected world.”

–Nuala O’Connor, Center for Democracy and Technology

**“WE WILL NOT REMAIN THE MOST INNOVATIVE ENTREPRENEURIAL NATION** unless we win what is now a global battle for talent, and we cannot win that battle for talent with our current immigration system.”

–Revolution CEO Steve Case

■ “We’ve come to realize at Microsoft that when it comes to our customers’ data, **our business model is becoming more like a bank’s**. At the end of the day, our reputation for how we deal with that data is really what’s going to allow us to continue to be successful.”  
—Horacio Gutiérrez, Deputy General Counsel, Microsoft

## Confronting Washington

Our **Techonomy Policy** event put an urgent focus on the many ways tech is outracing government. Few dared say the U.S. is sufficiently focused on the challenges and possibilities of a digital, real-time, interconnected economy.



“Most Americans can’t even think of **‘the Republican view of technology’** and **‘the Democratic view’**—because there’s really none—we’re looking for a lot of the same ends.”  
—U.S. Senator Cory Booker, New Jersey

“If we don’t fix the **FDA approval process and that bureaucracy**, 20 years from now we’re going to be **GOING TO CHINA TO BUY DRUGS** that were tested in China and the clinical trial was run in China, for a **10th or even a 100th of the cost.**” —Sean Parker, innovator



“**We struggle at the Federal Trade Commission**, just like every governmental agency does, to keep up with the incredible pace of technology... Probably we’re about six months behind industry. We used to be maybe five years behind, but six months is the equivalent of five years now.” —Commissioner Julie Brill of the FTC



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MONETIZING MENTAL EXPORTS OF GENIUS

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EXPENSIVE GADGETS, SOFTWARE

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# ROCK STARS OF TECH

■ THE RELATIONSHIP between the music and tech industries has long been tumultuous. Technology has simplified the recording, distribution, and marketing of music. But it has also enabled rampant theft of songs and encouraged new business models that make it harder for artists and their labels to make money. It's certainly gotten the music industry's attention. Having spent more than six years in that business before making my transition into tech and media, I have become obsessed not only with how music has been transformed but also with the similarities between the two communities.

Now more and more music industry veterans are finding their way into tech. Ten years ago, U2 lead singer Bono joined tech investors Roger McNamee and Marc Bodnick to form Elevation Partners. They

Techonomy's president spent years in music as tech wrought havoc. Now he finds musicians and industry execs no longer fighting change. Instead they're going all techie.

**By Josh Kampel**

have made a bunch of investments, including in Palm Computing, and had a big hit when they invested early in Facebook. Then, of course, there's Dr. Dre and music executive Jimmy Iovine. They launched Beats and made it huge before selling it to Apple. Jay Z has the Tidal streaming music service and Neil Young the Pono high-fidelity music player.

The prospect of riches has likely been a big motivator for all these people. But many of the personality traits that made them successful in music seem to translate directly into tech. I've had a few personal encounters recently that underscore the growing overlap between these two highly-creative arenas of business.

**S**TANDING in a dark club during the World Economic Forum in Davos, Switzerland, among CEOs and political leaders is kind of surreal. While we all wait for The Killers to take the stage, I look to my left and strike up a conversation with the person who just happens to be standing there—cultural icon and music superstar will.i.am. I had heard him earlier in the day speaking on a session hosted by Salesforce CEO Marc Benioff that also included business titans Marissa Mayer of Yahoo, Bank of America CEO Brian Moynihan, and Microsoft's Satya Nadella. will.i.am's comments were very "Techonomic," focusing on the impact of tech on the developing world. But he also slipped in a little promotion of a device he was wearing, a sort of watch, being developed by a company he started called i.am+.

In the club he shows me a prototype of this “smart cuff,” as he calls it, and I can see how proud he is of it. He walks me through some of the functions, highlighting the user interface and how you can connect to the Internet without needing a phone. He pauses, looking for an indication of my thoughts. It feels like an artist playing me a demo for the first time, something I experienced a lot when I worked as a manager. will.i.am tells me his celebrity is being used to promote other products from other companies, so why shouldn’t he have his own? But this doesn’t feel like just a vanity project. It is clearly something he’s passionate about. The device still hasn’t hit the market, so it’s hard to say how it will fare. The critics thus far have been brutal, but artists are not strangers to media scrutiny, right?

**I**n the midst of a group of tech entrepreneurs at a conference in Las Vegas, I run into a couple guys clad in the familiar tech uniform of jeans and untucked button down shirts. They blend in seamlessly with the rest of the pack. I ask about the company listed on their conference badge, Machine Shop Ventures. They start off with, “Well, we’re in a band...” and it’s *déjà vu* to my experiences in Los Angeles, where almost everyone I met said they were in a band. But then they complete the thought by saying “...called Linkin Park.” So I pay close attention. This is Mike Shinoda and Joe Hahn from the multi-platinum, Grammy Award-winning band. They explain how, working with their intern, they got so successful marketing themselves that other artists and labels began to hire them as marketers. That was



the genesis of Machine Shop.

Their business acumen was evident, but with all the competition in social media marketing, about a year ago they decided to pivot into venture capital. A few months later, I get together in Los Angeles for lunch with Shinoda, the group’s lead singer. He tells me he has personally invested in companies like Spotify and Sonos. “If you take a look at my Instagram, I post about drones and 3D printing,” he tells me, “but we invest in companies where we have something meaningful to offer.” We talk about the band’s investments in companies including car-service Lyft, Shyp, the on-demand shipping service,

and Robin Hood, a financial trading app that aims to democratize access to the stock market. “There’s not much difference between launching a new album or launching a new app,” Shinoda says.

“Before starting the fund, the band spent a lot of time honing in on why we are investing and what types of companies we are looking for,” says Kiel Berry. He runs the day to day operations at Machine Shop Ventures. “We actually just came back from a trip to San Francisco to visit with portfolio companies. The guys were superengaged and you could see their commitment to unlocking ways our ecosystem could add value to the companies.”



**Rock band Linkin Park's tech-oriented investment firm Machine Shop Ventures has invested in Lyft, Shyp, and other startups, some of which are not spelled with the letter "y."**

platforms to enable anyone to create custom dynamic musical messages. If you type in your message and choose a popular musical track, Zya creates a one-of-a-kind song with your message in place of the tune's lyrics. By the following October, the Ditty platform had helped people produce over 55 million unique musical messages. Matt Serletic says he's not at all surprised to see musical artists increasingly drawn to tech. "Technology helps people around the globe express themselves," he says. "It involves concepts such as architecture, structure, elegance. Musicians want to get involved in something like that."

In the music industry I experienced the disruptive introduction of MP3, Napster, and even a platform that promised to predict hit songs based on something similar to what we now call predictive analytics. People in the music industry have been profoundly affected by the way tech has transformed their business. "We are in a state of great transition in the music industry. It feels a bit like a roller coaster, with lots of ups and downs," says Serletic. Maybe that's why he and so many others like him are deciding to dive in. Or maybe it's the degree to which consumer tech is becoming so much like other consumer businesses of the past.

These people understand how to create, distribute, and market something they believe in. They understand the fickle consumer landscape. They are willing to do what's necessary to succeed. Sure, some celebrities just want to leverage their fame, but I know how much passion, creativity, and focus it takes to succeed in music. If these people apply that to tech, my bet is that there are likely to be more huge successes like Beats.

*Josh Kampel is the president of Technomy*

**B**eing in Austin during SXSW really underscores how intertwined the music and tech industries have become. This year I was introduced to Dean Serletic, who used to head A&R at Virgin Records (which means he signed new musicians). Now he runs marketing for Zya Music, a company that applies machine learning to democratizing music creation. We talk about what an emotional connection most people have to music, but how the average person lacks the musical skills and creative tools to express him or herself through song. Dean later introduces me to his brother Matt, Zya's CEO and former head of Virgin Re-

ords. Matt Serletic might not be a household name like will.i.am or Linkin Park, but he is responsible for one of the most notable collaborations of recent times, when guitar icon Carlos Santana joined Matchbox Twenty lead singer Rob Thomas to record the smash hit "Smooth."

Dean, Matt, and I get together a second time in San Francisco in March. They tell me they are about to make an announcement with a large partner, whom they won't reveal. Facebook's big F8 developer conference starts the next day, which turns out not to be a coincidence. Matt Serletic tells the world there that one of Zya's first products, Ditty, integrates with Facebook Messenger and other



# NEW TOOLS **TO TACKLE** THE BUSINESS DIVERSITY CRISIS

BY ANN BABE

■ **FOR BETTER OR WORSE**, we seem to prefer people similar to ourselves. This applies to the people we date and marry, the friends we keep, our neighbors, and the employees we hire. If anything, technology at the moment is making us even more that way, as dating apps, home-searching platforms, recruitment tools, and a range of other aggregation and sorting services help us find and hang out with people more like ourselves. But the consequences for business are terrible—almost every company is embarrassingly uniform in its makeup, even as data increasingly shows that in diversity is strength. Now, finally, software and other tools are emerging that may help reintroduce a more natural human variety to organizations.

Hiring women, minorities, and people who generally don't look and think like the boss is not just good for society. More diversified workforces help create more profitable and faster-growing

companies. Francesca Gino, a Harvard Business School professor, says research indicates workplace diversity boosts employee morale and increases employees' "desire to work more effectively and efficiently."

Gino also reiterates what we more or less know intuitively—that workforce diversity can enable a company to solve a greater variety of problems. "New ideas and processes brought into the organization can offer more solutions to customers," she says. It's not just her opinion. Research over several years at the MIT Center for Collective Intelligence shows that at least for women, our intuitions are right—workgroups with more women get more done. (That will not be a big surprise for slightly more than







half our readers, we presume.)

On stage at the Technomy 2013 conference, center Director Thomas Malone explained that a workgroup's collective intelligence was "significantly correlated" with its percentage of women. The more women in the group, the more creative it was, and the faster it could come up with innovative ideas and solve knotty problems. This is a radical message for the existing institutions of business.

Another obvious argument for diverse points of view inside a company is that a vast percentage of customers are female, and the United States is approaching a non-white majority. The argument is even more compelling if a company expects to sell into the vastest markets of all, developing countries.

Intel is one company that already aggressively seeks to hire a wider variety of employees, according to spokesperson Gail Dundas: "Without employees with diverse backgrounds ... Intel is ill-equipped to address the needs of a diverse market. Diverse teams and companies create more opportunities for innovation, creativity, and strategic thinking."

And all of this directly impacts the bottom line. In 2011, a Columbia University and University of Maryland study found that large companies that had women in top management had a considerably higher market value than those that didn't. And, in 2003, a University of Texas-Dallas study found that banks with higher-than-average racial diversity performed better financially.

But despite the arguments for diversity, big business has failed to foster it. Major corporations are still overwhelmingly run by white men. This is particularly evident in finance, law, and tech. But the tech

sector is the most troubling, partly because so many of its companies openly acknowledge the virtues of diversity while failing to achieve it.

It's impossible not to notice this hypocrisy. Says Angela Benton, founder of NewMe Accelerator, a San Bruno-based incubator for minority- and women-run startups: "Ever since I moved to Silicon Valley, it's perplexed me how this industry and community can lack diversity. As entrepreneurs, how can we claim to be creating the future when a part of our population is being left out?"

**N**OW TECH may be coming to its own rescue, as new human resources software and services aim to help managers overcome unconscious biases and attract and hire diverse candidates. Textio, for example, flags potential bias in the wording of job postings as employers type. Its software will alert you if you write that you seek, for example, a "rock star." That language alienates many women. Writing "high performer" may sound less sexy, but Textio tells you it has more unisex appeal. Unitive is another tool that aims to neutralize managers' prejudices while reviewing job applications. It is programmed not to equate engineering with maleness, not to presume men are more capable than women, not to avoid candidates with black- or Latino-sounding names, and not to favor graduates of historically white schools.

In what has become almost a firestorm of apologies, tech companies are publicly acknowledging their severe lack of diversity and pledging to do better. But it is glaringly apparent that awareness alone does not translate into change. The statistics show little progress. Google was the first tech giant to release

its diversity data in May 2014, and updated the numbers in May 2015. Almost nothing had changed in the raw numbers, despite the company spending \$115 million on diversity efforts in 2014. Google's percentage of women globally went from 30% to, well, 30%, and the percentage of blacks and Hispanics in the U.S. remained abysmally stuck at 2% and 3%, respectively. (All that investment, however, may have led to diverse employees occupying more senior positions.)

Many other major tech companies also proclaim their desire to diversify, yet most still do poorly. Since June of last year, LinkedIn has upped its percentage of global female employees from 39 to 42%. But the company still only has 2% black employees. At Facebook, the number of women in its global workforce improved by just 1 percentage point from June 2014 to June 2015, and its ultra-low black workforce percentage remained unchanged. Chief Operating Officer Sheryl Sandberg famously champions working women, but had to admit that the company is struggling. She recently unveiled corporate anti-bias training. "We know we still have a long way to go," Sandberg said in the announcement. "But by helping people recognize and correct for bias, we can take a step towards equality."

Possibly more important is aggressively identifying underrepresented talent. Companies can be bolder and more deliberate in how they unearth candidates. Top tech companies have generally been hiring minority computer scientists and computer engineers at only about half the rate that American universities have been graduating them.

Now a growing group of organiza-

tions aims to help. Recruitment platform Jopwell connects “underrepresented ethnic minority candidates” with employer partners that include Facebook, McKinsey, Morgan Stanley, and Square. And Paradigm is a diversity strategy firm that helps companies not only hire a diverse workforce but also retain it, by partnering with managers to design and implement comprehensive action plans.

Tech companies are also working to help underrepresented communities by launching their own support programs. Intel’s Diversity Scholar initiative offers internships for minority and female college students. The Google for Entrepreneurs NextWave program teams up with Code2040 to provide one-year entrepreneur-in-residence fellowships to African-American and Latino founders. Mean-

while, institutions like the NewMe Accelerator help women and minorities get access to training, mentorship, and funding opportunities.

Almost everybody believes that broader, more equitable access to technology education and resources could be a societal and tech industry game-changer. This would mean less expensive Net connections, more open data, and more extensive STEM education for all Americans. Organizations are emerging to help, including Women Who Code and Black Girls Code.

It’s possible to make a company more diverse. It’s just hard. And the bigger a company is, the more difficult it can be. But Intel, with more than 100,000 employees, shows progress is attainable. The company’s goal, says spokesperson Dundas,

is “to make its U.S workforce fully representative of the talent available from which it hires by 2020.” (That’s different than seeking to mirror the entire population.) Dundas says Intel is on its way: “Against a goal of 40% diverse hiring, the company was at 43.3% in early January.” The chip giant ties progress towards these goals to every manager’s annual bonus.

Joelle Emerson, the founder of Paradigm, is impressed. She says Intel’s early success is “a message to all companies that change is possible.” But here’s a measure of how far business and tech still has to go: at progressive Intel, the black workforce remains at just 4%.

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*Ann Babe writes about tech and travel and is Techonomy’s former editorial coordinator.*

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# THE FUTURE OF MANUFACTURING IS GOING TO HAVE A LARGE BIOLOGICAL COMPONENT.

HOW DO WE TAKE THE KNOWLEDGE WE HAVE FROM THE INERT WORLD, THE STUFF THAT'S ALL AROUND US, AND APPLY IT TO BIOLOGICAL STUFF?

—Autodesk CEO Carl Bass

**“Information is power,** and if we don't put our information out there for citizens and neighborhood groups to consume, we don't have a level playing field. So we're putting all that out there and neighborhood groups are just consuming it like crazy.”  
—Detroit city CIO Beth Niblock

■ **“You build all these...entities that make use of data...and there isn't necessarily malevolence, but THE END RESULT IS INEQUITABLE to people who don't have access.”** —Investor and civic tech activist Jon Gosier



“We treat machinery from an accounting standpoint better than we treat people. **WHEN I INVEST IN COMPUTERS I GET TO DEPRECIATE THAT INVESTMENT OVER TIME.**

When I train a person, I have to expense all of it immediately. So when it comes to ‘Should I invest in a machine that could do that person's job or should I invest in a person?’ the economic rationale would be that the machine is cheaper.”

—Aetna CEO Mark Bertolini



Photographs by Rebecca Greenfield

■ “Why is it okay to have an automation asset on the factory floor that’s 40 years old? **The manufacturing industry hasn’t caught up to what we see in consumer electronics.**” — Raj Batra, U.S. President, Siemens Digital Factory Division

## Don’t Give up on Detroit...

...or the U.S. economy. The city’s failures show how far the country needs to go to grapple with how tech changes jobs, growth, competitiveness, and cities. For a bracing day at Wayne State University we asked: what next?



“Federalism is a huge challenge for those of us who believe in civic technology. There are **nearly 8,000 government agencies responsible** for U.S. elections alone. And there are very few widely-adopted data standards.”

—Tiana Epps-Johnson, Founder, Center for Technology and Civic Life

■ “I said to (CIO) Beth (Niblock), **‘HELP ME SET UP THIS 311 SYSTEM,’** and she’s like, **‘YOU ARE SO 1980s.’** So we took a version of (app) SeeClickFix, which we call Improve Detroit. **YOU CAN GO ONTO YOUR SMARTPHONE, PUT IN YOUR LOCATION, REPORT THE BROKEN STREET LIGHT, THE ILLEGAL DUMPSITE.’**”

—Detroit Mayor, Mike Duggan

### ■ **“HEALTH IS AN ASSET.**

IT’S A COMMUNITY ASSET. HEALTHCARE IS A REPAIR JOB WHEN YOU’VE LOST THE ASSET OF HEALTH, BECAUSE YOU RENTED IT RATHER THAN INVESTING IN IT.” —Investor and healthcare activist, Esther Dyson

### ■ **“Why do we call a maker city a jazz city?**

**There’s so many new ideas and materials to combine, new ways of working, and code that the only way we’re going to arrive at new solutions is through A GREAT DEAL OF IMPROVISATION.**” —Peter Hirshberg,

Re:Imagine Group

# GLOWING RABBITS AND SCULPTURES THAT BREATHE: THE RISE OF BIOART

By Isabel Walcott Draves

■ AS IT BECOMES more and more evident that manipulating DNA and intervening in other sophisticated ways in biology's processes will play a significant role in the human future, artists are taking notice. "BioArt" is a growing movement that involves either literally using living organisms as part of a work of art or imitating life processes and biological research to create art that critiques or embraces life sciences. Artists have created glowing bunnies, sculptures that breathe, and even encoded sexual drawings in living cells. That last triumphant project is, believe it or not, the piece that got the whole movement started.

These projects seldom resemble real science. They are more often instead what one might call science inspired. BioArt generally aims to encourage us to consider more carefully how people build and alter environments and the impact that has on living things. It harnesses science to spur curiosity and imagination, and to introduce to us new ways of thinking about the future. It can be educational, political, conceptual, or reflective. When it's good, it evokes a



This bio-sculpture by London design laboratory Loop.ph "breathes" based on data from sensors that measure local changes in UV light, heat, and carbon dioxide.

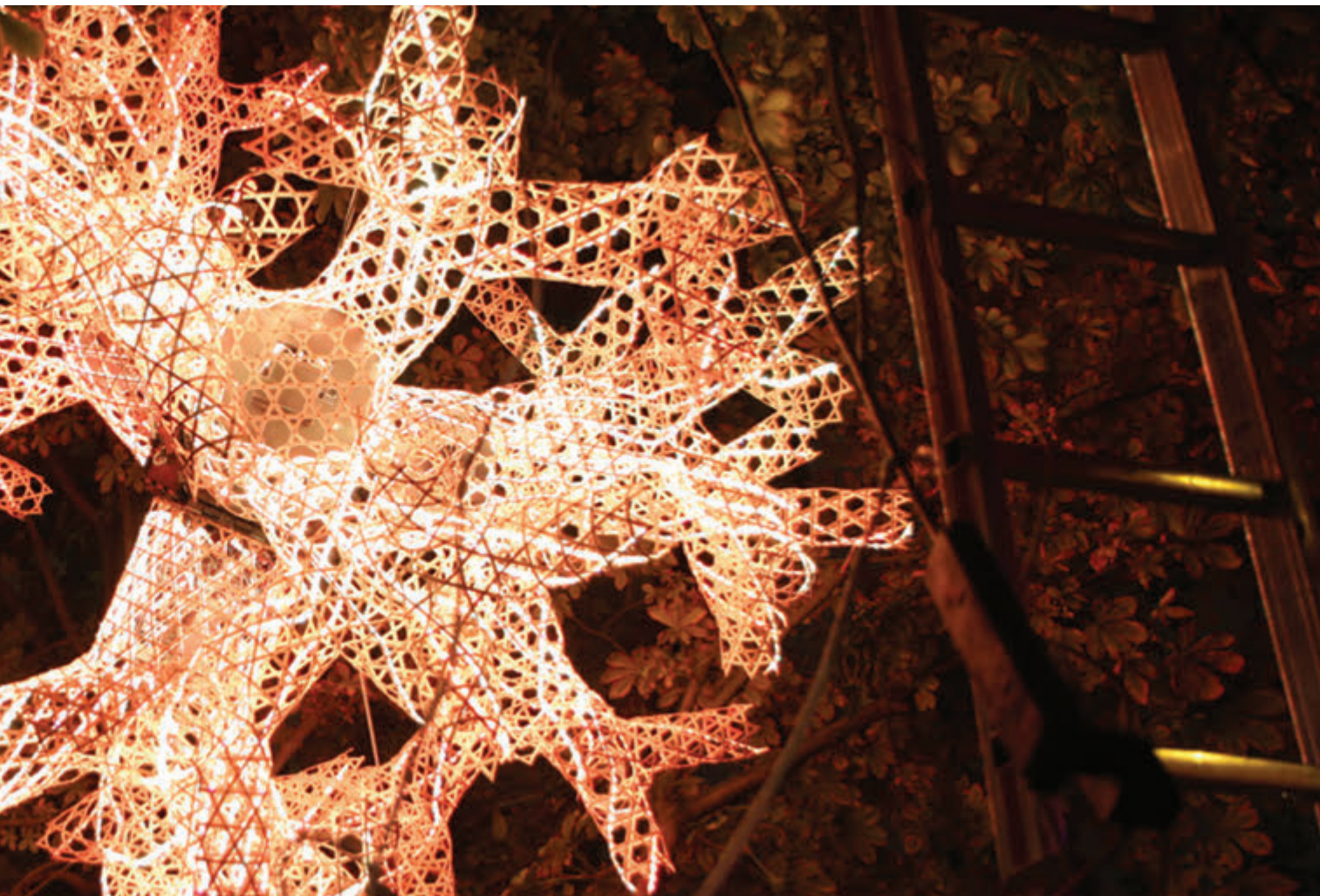
strange beauty, sometimes even playfulness, and something we may find lacking in many legitimate scientific pursuits: a sense of humor.

While it has recently gained significant momentum, BioArt began near the end of the 20th century. Joe Davis is considered the kooky granddaddy of BioArt. In 1988, his “Microvenus” encoded a crude sketch of a female reproductive body part in DNA base pairs (which function something like the 1’s and 0’s of binary computer code) and transferred it into live *e. coli* bacteria. More recently, in 2012 Davis won the Prix Ars Electronica

Golden Nica, a significant prize in the tech art world, with his “bacterial radio,” which employed circuitry made out of conductive bacteria. Davis has been loosely affiliated with a synthetic biology lab at Harvard Medical School and the MIT Department of Biology.

Davis’s work is related to that of the Brazilian-American artist Eduardo Kac, now Professor of Art and Technology Studies at the School of the Art Institute of Chicago. In 1997, in a performance broadcast on live TV, Kac microchipped and registered himself as both pet and owner in an

online registry designed for the recovery of lost animals. A 1999 work, *Genesis*, involved creating a synthetic gene by converting a sentence from the Bible into Morse code, and then converting the Morse code into DNA base pairs based on a principle developed for this specific purpose. (The sentence: “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.”) Kac incorporated the gene into bacteria which subsequently mutated, changing the encoded sentence and ironically muddling its anthropocen-



tric presumption.

Kac is credited with coining the term “BioArt” and is one of its best-known practitioners. He famously implanted a live white rabbit with a jellyfish gene for green fluorescence in 2000. The so-called “GFP bunny” glowed green when positioned under blue light. His experiment was repeated in 2013 by a team of actual scientists in Istanbul. In 2009, Kac won the Golden Nica for his transgenic work “Edunia,” a genetically engineered petunia flower that expresses his own DNA in its petals.

Although she’s not manipulating DNA in a synbio lab, artist Natalie

Jeremijenko, associate professor in the Visual Art Department at NYU, has been creating art incorporating plants and animals in her processes for more than

20 years. Its “bio” character manifests more as environmentalism. As part of her “Mussel Choir” in 2013 she outfitted live mussels with sensors to measure their filtering effect on water pollutants, converting the data into sound to make public art. Jeremijenko’s recent “Butterfly Bridge” project hung a hammock of flowers across a road in Long Island City, Queens, in a symbolic, optimistic effort to squeeze in a rest stop for butterflies in a diminishing habitat.

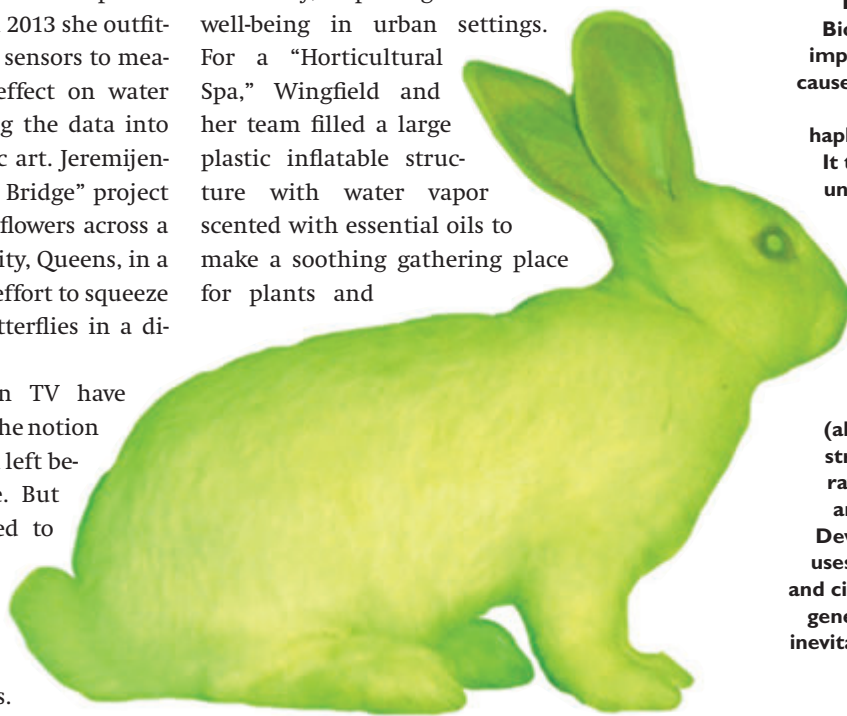
Forensic shows on TV have made commonplace the notion of collecting the DNA left behind at a crime scene. But have you ever paused to think about what we leave behind when we haven’t committed a crime? Heather Dewey-Hagborg has.

Her “Stranger Visions” project in 2013 collected human genetic material from public places with things like hair, cigarettes, and gum. Then, using contemporary scientific techniques, she attempted to reconstruct the facial features, skin tone, and appearance of the unwitting DNA “donors” to arrive at their possible portrait. As she did, she realized how much was left open to her interpretation as an artist – in other words, how unscientific the scientific technique was. Building on her learnings from that project, she wrote a 2015 exposé explaining that today’s state-of-the-art forensic techniques in DNA phenotyping rely on stereotypes and averages, making them less likely to be accurate and opening up the door to racial profiling.

While Dewey-Hagborg explores which biotechnologies might be divisive, Rachel Wingfield creates environments that bring people together. Co-founder of Loop.ph, Wingfield runs what she likes to call a spatial laboratory, exploring health and well-being in urban settings. For a “Horticultural Spa,” Wingfield and her team filled a large plastic inflatable structure with water vapor scented with essential oils to make a soothing gathering place for plants and

people. The arched entrance to the dome-like, foggy room is a wooden lattice covered with potted plants to resemble a cathedral entrance. Some people spent hours breathing in the mist in a temporary installation of the spa on the Thames River Path in London’s South Bank. As Wingfield describes it, the community embraced the artwork, which was commissioned to bring together a divided neighborhood undergoing the process of gentrification.

Wingfield creates “biomimetic” art, that is, projects inspired by biological models. She works with



**In an early work of BioArt, Eduardo Kac implanted a gene that causes jellyfish to phosphoresce into this hapless rabbit in 2000. It then glowed green under blue light. Kac later blended his own genes into those of a petunia to create a so-called “transgenic” work he called “Edunia,” (above). Gum on the street (above, left) is raw material for the artwork of Heather Dewey-Hagborg, who uses it along with hair and cigarettes to gather genetic information in inevitably vain attempts to reconstruct people’s faces.**



light-emitting fibers that imitate bioluminescence, and uses as models microscopic carbon nanostructures which she reproduces at macro scale to build lightweight building-like structures. For a site-specific installation called “Arborescence,” commissioned for a festival in Amsterdam, Loop.ph made a 9m tall sculpture that floated in the Amstel river and resembled a bioluminescent plant form. When Loop.ph recently made a sculpture out of inflatable plastic that recalls a living organism, Wingfield described it as “breathing in and out” based on the data it receives from local sensors that measure the presence of ultraviolet light, heat, and carbon dioxide (see photo).

In a flight of fancy in 2014, Wingfield and collaborator Lucy McRae invented what they call a “biological

bakery” as part of a music video for the pop group Architecture in Helsinki. Their “entirely edible DIY bio fab lab,” as they describe it, imagines “cloned body parts that are dipped and rotated *en masse* in huge vats of bacterial skin” and “hints at how synthetic biology could develop in the home.” Wingfield’s installations are based more on an appreciation for science than its actual practice, and yet the art resonates with viewers, perhaps because of that accessibility.

Techonomy featured BioArtist Suzanne Anker, chairperson of the fine art department at New York’s School of Visual Art, in the early 2014 issue of this magazine. Her interest is “the way in which visual art and the biological sciences intersect because of technology.” At SVA she has created a real lab where artists work alongside

scientists doing research. Anker’s own work ranges from living plant sculptures grown in the gallery to petri-dish-like 3D printed objects that suggest a scientific experiment gone haywire.

Life science innovation will be increasingly evident in society going forward. Some will be shocking, some amazingly useful, and some will be foreshadowed by today’s BioArt. This will provoke greater discourse, and, in turn, more BioArt. That crude silly sketch on a bacterium back in 1988 pointedly poked fun, but it foretold a new era in science.

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*Isabel Walcott Draves is founder of Leaders in Software and Art, a community of artists who work with technology. She is currently organizing Creative Tech Week, a citywide celebration of the intersection of technology with creativity, scheduled for the first week of May 2016 in New York.*



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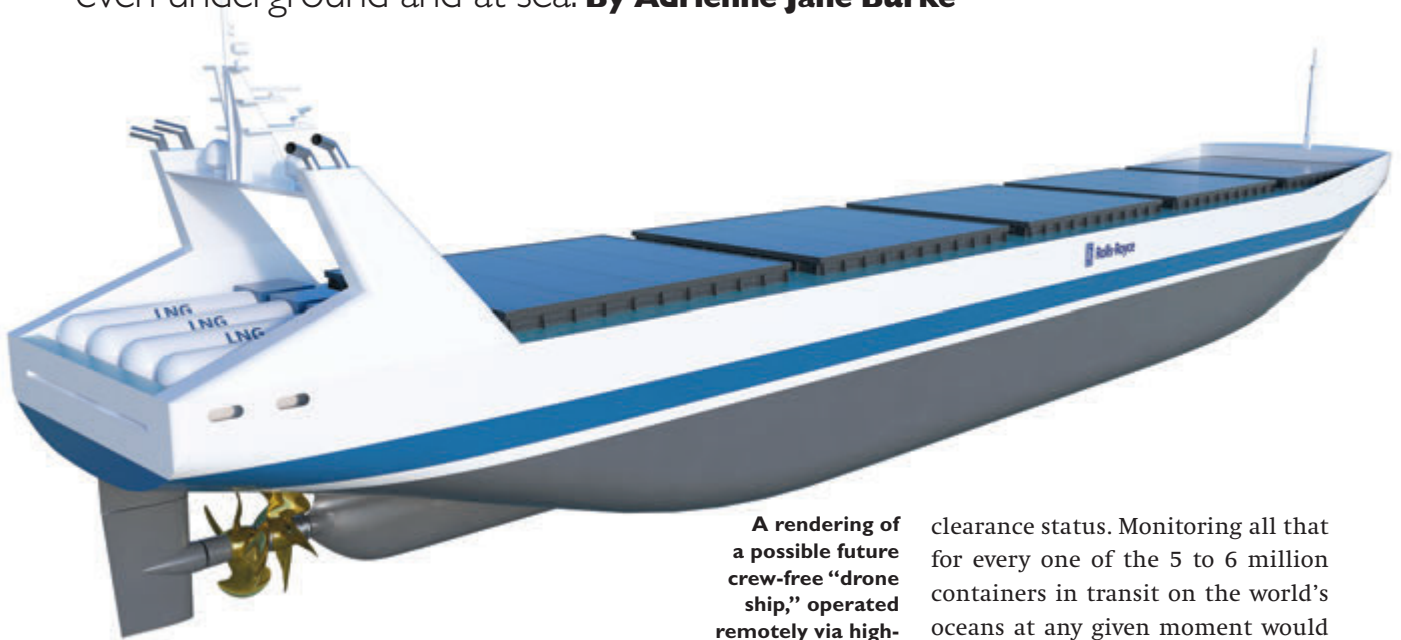
# THE EMERGING SCIENCE OF INNOVATION

Steelcase researchers have identified 8 different structural models of innovation within organizations, each with its own implications for how to use space to improve the speed and outcomes of innovation efforts. Simply stated, the right spaces make innovation work.

To read more about this research, visit [steelcase.com/innovation](http://steelcase.com/innovation).

# THE NEXT INDUSTRIES TO BE TRANSFORMED BY TECH: SHIPPING AND MINING

Wireless and autonomous systems will increasingly manage the work, even underground and at sea. **By Adrienne Jane Burke**



**A rendering of a possible future crew-free “drone ship,” operated remotely via high-speed wireless connections.**

clearance status. Monitoring all that for every one of the 5 to 6 million containers in transit on the world’s oceans at any given moment would be a data revolution. It will eventually happen.

But other technologies will also soon transform how the world’s 100,000-plus ocean-going merchant ships are managed, operated, and maintained. Consulting and services firm Lloyd’s Register says the carrier of the future will be “smarter, data driven, greener...fully connected wirelessly onboard, and digitally connected through global satellites.”

Such ships might also be unmanned. Lloyd’s predicts tankers and cargo carriers will be guided by sensors, automation, big data, and global networks. Indeed, Rolls-Royce got to work this summer on a \$7.5 million research project for the Finn-

■ In the 2009 sci-fi movie *Sleep Dealer*, laborers in a near-future dystopian world work in a Tijuana factory where, plugged into a digital network, they remotely operate robots to erect skyscrapers in New York City and fly drones over the desert. It’s another fantasy already coming true. Remotely controlled earth-movers, sensor-connected containers, and network-linked augmented reality goggles are coming to mining and shipping, industries thus far almost wholly unreconstructed by mobile tech. The Internet of Things (IoT) is going underground and out to sea.

## NETWORKED SHIPS, WITH OR WITHOUT CREW

The 18,000 containers aboard a vast new vessel unveiled this month by shipping giant CMA CGM are more than just climate-controlled cargo boxes. Embedded with technology from French IoT startup TRAXENS, each container is a smart connected object, able to share data with other containers, with the crew’s mobile devices, and with company HQ in Marseille. The devices relay the container’s location, temperature, humidity level, vibrations, any impacts or attempted break ins, and customs

ish Funding Agency for Technology and Innovation to produce specs and designs for a fully remote-controlled ship. Naval architect Oskar Levandar, vice president for innovation in Rolls-Royce's Marine group, says "the main driver is to drive down costs and improve efficiencies, but the idea isn't new." The difference now in shipping, he says, "is that this is technically feasible, and society is more mature to accept this kind of solution." That last thought may be slightly optimistic. We'll see.

Even when seamen remain, technology will transform large-scale shipping. Maersk Line set out to create the world's first mobile communication-connected fleet in 2011. It wanted information to flow in real-time between ships and shore to simplify processes, improve productivity, and enable quicker, better informed decisions.

The mobile and satellite communication technologies now on more than 350 Maersk ships enable more efficient routes and save \$50 million in fuel costs each year. Refrigerated containers on each vessel are monitored wirelessly, and Internet access improves life on the ship, according to Maersk's mobile partner Ericsson.

Augmented reality will also improve shipping. Finnish machinery company Wärtsilä this year unveiled network-linked goggles in its ship-board maintenance services. An on-board engineer with a headset can share real-time video and audio with land-based colleagues to collaborate on fixing an engine.

Among the challenges to implementing such new technologies in an old industry? Skilled workers. The

crew that remains must be professionals in engineering, technology, and data analysis.

Some are already wistful for the fast-fading traditional career. A recent article in industry publication IHS Maritime 360 quoted a union representative asking "Are seafarers destined to become screenwatchers and machine minders?"

## MINING ORE FROM A CUBICLE

At a pilot project run by Ericsson, operators in a control room outside a Swedish mine are testing a remote-controlled Volvo truck to transport ore. Such innovations will not only keep miners out of dangerous underground conditions, but Ericsson executives say the technology also creates new economic opportunities. Operators may work in distant mines without leaving their hometown or the safety of an office park. And mineral reserves could be extracted even from the most inhospitable and remote regions.

Visitors to the enormous Ericsson exhibit at Mobile World Congress in Barcelona this year could try such a system. They climbed into the cab of a virtual excavator and donned a virtual reality headset. They then proceeded to dig real holes in a Stockholm parking lot 1,700 miles away, where a six-ton machine was connected via a mobile wireless network. Greg Harper, a New York tech entrepreneur who remote-scooped a pile of gravel from the convention floor, said, "I go to a lot of shows. It takes a lot to impress me. This blew my mind." He was one of sev-

eral hotdog showgoers who proudly claimed their aggressive and expert digging almost knocked over the Stockholm excavator.

In fact, the concept is already being tested in the real world. Ericsson and several partners in mining and equipment launched a project this year to implement advanced wireless tools to improve productivity and safety for Swedish mines. Ericsson's Torbjörn Lundahl, program manager for next-generation 5G wireless systems, says remote-controlled loaders could be sent into a mine after a blast to keep operations running while protecting workers from dangerous dust. Emerging 5G systems—the next generation in wireless—will be able to communicate more instantaneously over long distances than today's networks, so if you are about to knock over your mining machine, you will be able to adjust the controls in time to keep it steady. Future machines will either be autonomous or controllable from anywhere in the world.

Remote control isn't new to mining. The LKAB ore mine in Kiruna, Sweden, which claims to be the world's most modern, has used a remote-controlled underground transport system since 1972, and today most of its underground production is automated. But it relies on a manned command station 775 meters underground and signals transmitted to locomotives via cables on the tunnels' ceilings. Mines enabled by 5G wireless will make such a set-up look like Fred Flintstone's Bedrock Gravel Company.

*Adrienne Jane Burke is a longtime science and technology journalist*



# As Tech Changes the World, Techonomy Curates Conversation

■ At Techonomy we do much more than organize conferences. The seventh annual main event continues at the Ritz-Carlton in Half Moon Bay next November, and we are also planning the first Techonomy conference in our hometown of New York in May. It will be a one day event, as wide-ranging in content as the one in California. Throughout the year we convene gatherings of various sizes, including dinners, workshops on specific topics, internal company conversations, and other sorts of dialogue. Hosting events, publishing on the web, and making the occasional magazine keeps the small crew you see below plenty busy. But it's impossible to read the news each day without being jarred by amazing new tech-infused developments that seem to emerge in every industry, country, and sector of society. Our job will remain helping leaders put it into context and figure out the opportunities it creates to build a better world.



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Few venues are more stunning than the Ritz-Carlton Half Moon Bay, where the Techonomy conference takes place in 2016 for the third consecutive year. Our first New York event will be in May.

**Techonomy New York**  
 May 2016  
 New York, New York

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**Techonomy 2016**  
 November 9-11  
 The Ritz-Carlton  
 Half Moon Bay, California

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For details see  
[techonomy.com](http://techonomy.com)



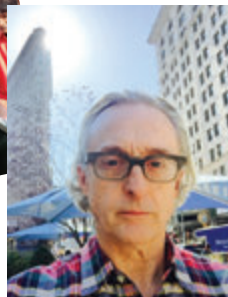
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Director of Program Operations



**ALEX CUDABACK**  
Program Director



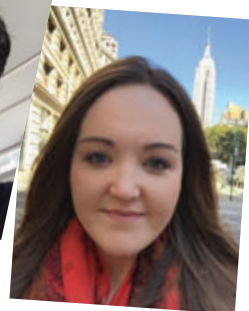
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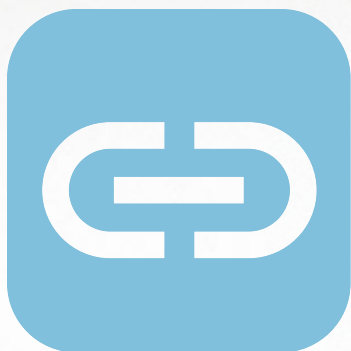
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helps leaders understand the transformative role that technology plays in social and economic progress.

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