MIT Technology Review

VOL. 118 NO. 3 MAY/JUNE 2015 $6.99

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INNOVATION

THIS IS WHAT WE DO.

From the Editor

Three years ago, when CRISPR-Cas9, a method of precisely editing DNA, suddenly appeared liked a technology from the future, scientists realized we could now engineer the human race by giving our children and their heirs improved genes. But many disavowed that we would do so soon.

The biologist Weizhi Ji, who created two gene-edited macaque monkeys at Kunming Biomedical International, said that creating humans with CRISPR-edited genomes was "very possible," but added that "considering the safety issue, there would still be a long way to go." (See "10 Breakthrough Technologies: Genome Editing," May/June 2014.)

Yet I was sure that scientists would research how to edit the human germ line, and quickly. ("Germ line" is biologists' jargon for the egg and the sperm, which combine to form an embryo. Editing the DNA of such cells, or of the embryo itself, would pass heritable changes to future generations.)

They would try because editing genes with CRISPR was trivially easy, and it would be a sensational thing to do. "Any scientist with molecular biology skills and knowledge of how to work with [embryos] is going to be able to do this," says Jennifer Doudna, a biologist at the University of California, Berkeley, who in 2012 co-discovered how to use CRISPR to edit genes.

Mostly, they would research CRISPR because it seems a powerful way to prevent disease from birth. Guoping Feng, a neurobiologist at MIT's McGovern Institute for Brain Research, believes that gene-edited human beings are "10 to 20 years away," but nonetheless approves of human germ-line editing. Feng says, "To me, it's possible in the long run to dramatically improve health, lower costs. It's a kind of prevention."

Why not use CRISPR to eliminate diseases like Huntington's, a terrible, fatal neurodegenerative disorder triggered by a defect in a single gene? Or why not correct the DNA of an embryo with a mutation in a gene called *BRCA1*, which causes ovarian and breast cancer? While you're fiddling with an embryo's DNA, why not insert naturally occurring gene variants that confer extraordinary characteristics like unbreakable bones or resistance to diseases like Alzheimer's?

As our biomedicine editor, Antonio Regalado, reports in this issue's cover story, "Engineering the Perfect Baby" (page 26), experiments designed to correct the DNA in a woman's egg or a man's sperm, or to directly edit the DNA of an early-stage embryo using CRISPR, are already being carried out.

Why not? One concern is that the technologies would not be widely available, at least at first. Their expense would mean only rich people would have perfect children. Another worry is that germ-line engineering would affect unborn people without their consent. The most potent objection is that we don't know what we're doing: if you provide immunity to a disease, you might break something in a genome.

History insists that when a technology has obvious utility, it will be used. But *how* we use a new technology is our choice. In March, writing in the journal *Science*, a group of scientists including Doudna and two Nobel laureates called for a great debate on the genetic engineering of humans and a moratorium on any effort to create engineered babies. Crucially, the scientists did not ask their peers to stop using CRISPR to edit human embryos for research purposes; but they recommended convening a "globally representative" group of government agencies, ethics experts, and scientists to suggest policies to guide that research.

Let's have that debate. Write to me at jason.pontin@technologyreview.com.

GUIDO VITTI

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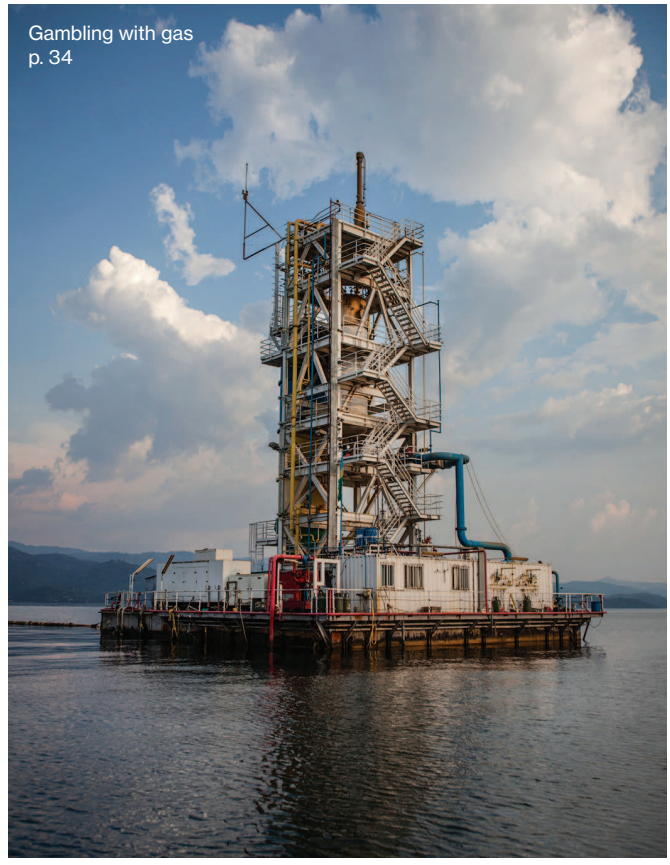

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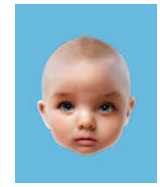

Illustration by Arn0

PHOTOGRAPH BY JASON FLORIO

Morgan Stanley

Capital Creates More Commerce

New technology can make even small businesses big. E-commerce leader Alibaba Group built an online and mobile marketplace connecting small businesses to customers in China and beyond. Morgan Stanley helped take the company public, leading a $25 billion IPO — the largest in history. Alibaba's subsequent growth is helping fulfill the company's ambition of giving rural communities access to goods and services once considered out of reach. Across the globe, we're working to advance the technologies that help more people to prosper. Capital creates change.

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Technology Review
One Main Street, 13th Floor
Cambridge, MA 02142
Tel: 617-475-8000

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De Technologia non multum scimus. Scimus autem, quid nobis placeat.

INNOVATION BY DESIGN

R&D Funding Program

The National Reconnaissance Office Director's Innovation Initiative (DII) Program funds cutting-edge scientific research in a high-risk, high-payoff environment to discover innovative concepts and creative ideas that transform overhead intelligence capabilities and systems for future national security intelligence needs. The program seeks out the brightest minds and breakthrough technologies from industry, academia, national laboratories, and U.S. government agencies.

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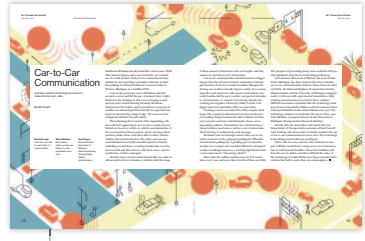
Five Most Popular Stories

MIT Technology Review
Volume 118, Number 2



1

10 Breakthrough Technologies: Magic Leap

The real value of Magic Leap's platform is its potential light field display, combined with very complicated algorithms. We don't know whether Magic Leap has solved these problems or not—but we do know their demo and technical feasibility plan were solid enough to convince investors to put down half a billion dollars.

—Juan David Hincapié-Ramos

This is just another reason to detach from reality and focus on someone else's version of reality.

—psenatori

2

10 Breakthrough Technologies: Car-to-Car Communication

If traffic lights communicate to let cars adjust their speed to arrive only at green lights, everyone is going to want this.

—Gary Kreie

The auto industry has a long way to go to understand the hazards of connected cars, as shown by researchers hacking Tesla and BMW. Those hacks were just a nuisance, like unlocking the doors, but what happens when people start trusting warnings from other cars approaching, when that information has been manipulated?

—apptimates

3

Why We Don't Have Battery Breakthroughs

It is not realistic to expect "breakthroughs" in any area of technology. They rarely occur, and are almost never the product of efforts directed at a specific result. Instead, battery technology will advance at a slow, steady pace, improving a little year after year.

—big.league.slider

I'm an electric-car advocate but I can see that giving up the ability to drive as far as you want is enough to make people think twice. Fast recharge will fix the problem faster than increased range—for me, at least. **—asdar**

4

10 Breakthrough Technologies: Internet of DNA

We need better models of consent for the sharing of genomic data, but there won't be one solution that works globally: each country will have to develop its own response, guided by the work at the international level.

—Chris Arnold, chairman Human Variome Project International

Most privacy concerns are not rational assessments of the real risk of your information being processed. I would want everyone's DNA databased if it meant I could spend five more years with my parents. **—orangesherbet**

5

Our Fear of Artificial Intelligence

The purpose of technology is not to enable human ability. The purpose is to make money. We shouldn't fear intelligent bots, but we should be deathly afraid of those who make and sell them. **—ar18**

The easiest pathway to super-intelligence, whole-brain emulation, does not require any theoretical breakthroughs, just better technology than we now have. I see no value, given the potential ramifications of such technology, in pretending that there is nothing to worry about.

—HockeyAndReason