

Introduction

Not all breakthroughs are created equal. Some arrive more or less as usable things; others mainly set the stage for innovations that emerge later, and we have to estimate when that will be. But we'd bet that every one of the milestones on this list will be worth following in the coming years.

-The Editors

Magic Leap

A startup is betting more than half a billion dollars that it will dazzle you with its approach to creating 3-D imagery.

Availability: 1-3 years

Nano-Architecture

A Caltech scientist creates tiny lattices with enormous potential.

Availability: 3-5 years

Car-to-Car Communication

A simple wireless technology promises to make driving much safer.

Availability: 1-2 years

Project Loon

Billions of people could get online for the first time thanks to helium balloons that Google will soon send over many places where cell towers don't reach.

Availability: 1-2 years

Liquid Biopsy

Fast DNA-sequencing machines are leading to simple blood tests for cancer.

Availability: now

Megascale Desalination

The world's largest and cheapest reverse-osmosis desalination plant is up and running in Israel.

Availability: now

Apple Pay

A clever combination of technologies makes it faster and more secure to buy things with a wave of your phone.

Availability: now

Brain Organoids

A new method for growing human brain cells could unlock mysteries of dementia, mental illness, and other neurologic disorders.

Availability: now

Supercharged Photosynthesis

Advanced genetic tools could help boost crop yields and feed billions more people.

Availability: 10-15 years

Internet of DNA

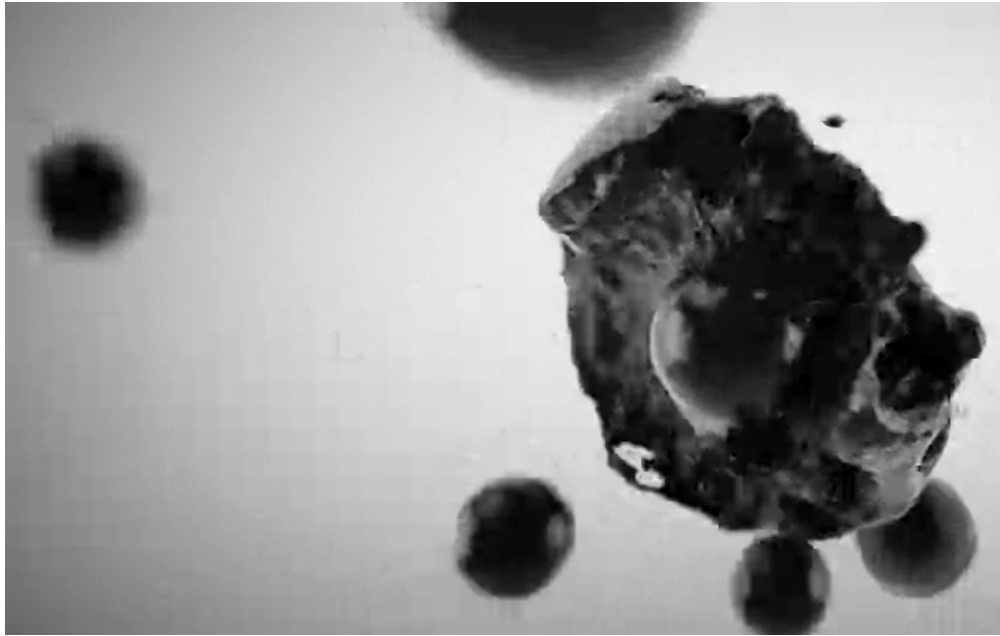
A global network of millions of genomes could be medicine's next great advance.

Availability: 1-2 years

GET STARTED

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Introduction

Technology news is full of incremental developments, but few of them are true milestones. Here we're citing 10 that are. These advances from the past year all solve thorny problems or create powerful new ways of using technology. They are breakthroughs that will matter for years to come.

-The Editors

Agricultural Drones

Relatively cheap drones with advanced sensors and imaging capabilities are giving farmers new ways to increase yields and reduce crop damage.

Ultraprivate Smartphones

New models built with security and privacy in mind reflect Zeitgeist of the Snowden era.

Brain Mapping

A new map, a decade in the works, shows structures of the brain in far greater detail than ever before, providing neuroscientists with a guide to its immense complexity.

Neuromorphic Chips

Microprocessors configured more like brains than traditional chips could soon make computers far more astute about what's going on around them.

Genome Editing

The ability to create primates with intentional mutations can provide powerful new ways to study complex and genetically baffling brain disorders.

Microscale 3-D Printing

Inks made from different types of materials, precisely applied, are greatly expanding the kinds of things that can be printed.

Mobile Collaboration

The smartphone era is finally getting the productivity software it needs.

Oculus Rift

Thirty years after virtual-reality goggles and immersive virtual worlds made their debut, the technology finally seems poised for widespread use.

Agile Robots

Computer scientists have created machines that have the balance and agility to walk and run across rough and uneven terrain, making them far more useful in navigating human environments.

Smart Wind and Solar Power

Big data and artificial intelligence are producing ultra-accurate forecasts that will make it feasible to integrate more renewable energy into the grid.

GET STARTED

Credit: Animation by Make

Tagged: EmTech2014, TR10 2014

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10 BREAKTHROUGH TECHNOLOGIES 2013

[Introduc](#)

Deep Learning

With massive amounts of computational power, machines can now recognize objects and translate speech in real time. Artificial intelligence is finally getting smart.

Temporary Social Media

Messages that quickly self-destruct could enhance the privacy of online communications and make people freer to be spontaneous.

Prenatal DNA Sequencing

Reading the DNA of fetuses will be the next frontier of the genomic revolution. But do you really want to know about the genetic problems or musical aptitude of your unborn child?

Additive Manufacturing

Skeptical about 3-D printing? GE, the world's largest manufacturer, is on the verge of using the technology to make jet parts.

Baxter: The Blue-Collar Robot

Rodney Brooks's newest creation is easy to interact with, but the complex innovations behind the robot show just how hard it is to get along with people.

Memory Implants

A maverick neuroscientist believes he has deciphered the code by which the brain forms long-term memories. Next: testing a prosthetic implant for people suffering from long-term memory loss.

Smart Watches

Ultra-Efficient Solar Power

Big Data from Cheap Phones

The designers of the Pebble watch realized that a mobile phone is more useful if you don't have to take it out of your pocket.

Doubling the efficiency of a solar cell would completely change the economics of renewable energy. Nanotechnology just might make it possible.

Collecting and analyzing information from simple cell phones can provide surprising insights into how people move about and behave – and even help us understand the spread of diseases.

Supergrids

A new high-power circuit breaker could finally make highly efficient DC power grids practical.

10 BREAKTHROUGH TECHNOLOGIES

2012

These are the 10 most important technological milestones reached over the previous 12 months. To compile the list, the editors of *MIT Technology Review* select the technologies we believe will have the greatest impact on the shape of innovation in years to come. This impact can take very different forms, but in all cases, these are breakthroughs with the potential to transform the world.

Year: 2012



Egg Stem Cells
A recent discovery could increase older women's chances of having babies.



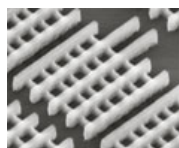
Ultra-Efficient Solar
Under the right circumstances, solar cells from Semprius could produce power more cheaply than fossil fuels.



Light-Field Photography
Lytro reinvented the camera so that it can evolve faster.



Solar Microgrids
Village-scale DC grids provide power for lighting and cell phones.



3-D Transistors
Intel creates faster and more energy-efficient processors.



A Faster Fourier Transform
A mathematical upgrade promises a speedier digital world.



Nanopore Sequencing
Simple and direct analysis of DNA will make genetic testing routine in more situations.



Crowdfunding
Kickstarter is funding the commercialization of new technologies.



High-Speed Materials Discovery
A new way to identify battery materials suitable for mass production could revolutionize energy storage.



Facebook's Timeline
The social-networking company is collecting and analyzing consumer data on an unprecedented scale.

Past 10 Breakthrough Technologies Lists:

2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2001



10 BREAKTHROUGH TECHNOLOGIES

2011

Every year, Technology Review looks at the advances that have happened over the previous year and chooses 10 emerging technologies that we think will have the greatest impact. The ultimate criterion is straightforward: is the technology likely to change the world? This year's group includes high-energy batteries that could make cheaper hybrid and electric vehicles possible and a new class of electrical transformers that could stabilize power grids. Some of our choices will alter how you use technology: you'll be tapping into computationally intensive applications on mobile devices, or using gestures to command computers that are embedded in televisions and cars. Other choices could improve your health; for instance, doctors will craft more effective cancer treatments by understanding the genetics of individual tumors. But no matter the category, all 10 promise to make our lives better.

Watch the TR10 Video Introduction

Year: 2011 ↕



Social Indexing
Facebook remaps the Web to personalize online services



Homomorphic Encryption
Making cloud computing more secure



Smart Transformers
Controlling the flow of electricity to stabilize the grid



Cloud Streaming 🚩
Bringing high-performance software to mobile devices



Gestural Interfaces
Controlling computers with our bodies



Crash-Proof Code
Making critical software safer



Cancer Genomics
Deciphering the genetics behind the disease



Separating Chromosomes
A more precise way to read DNA will change how we treat disease



Solid-State Batteries 🚩
High-energy cells for cheaper electric cars



Synthetic Cells 🚩
Designing new genomes could speed the creation of vaccines and biofuel-producing bacteria

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10 BREAKTHROUGH TECHNOLOGIES

2010

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Year: 2010 ▾



Real-Time Search 🚫
Social networking is changing the way we find information.



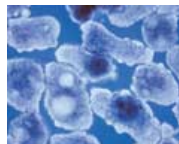
Social TV 🚫
Relying on relationships to rebuild TV audiences.



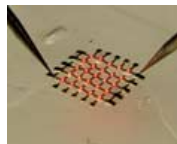
Mobile 3-D 🚫
Smart phones will take 3-D mainstream.



Green Concrete 🚫
Storing carbon dioxide in cement.



Engineered Stem Cells
Mimicking human disease in a dish.



Implantable Electronics 🚫
Dissolvable devices make better medical implants.



Solar Fuel 🚫
Designing the perfect renewable fuel.



Dual-Action Antibodies 🚫
Fighting cancer more efficiently.



Light-Trapping Photovoltaics 🚫
Nanoparticles boost solar power's prospects.



Cloud Programming 🚫
A new language will improve online applications.

Past 10 Breakthrough Technologies Lists:

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10 BREAKTHROUGH TECHNOLOGIES

2009

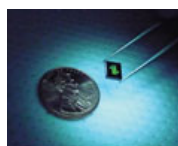
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Year: 2009



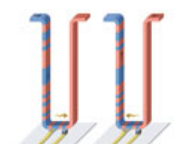
Intelligent Software Assistant

Adam Cheyer is leading the design of powerful software that acts as a personal aide.



\$100 Genome

Han Cao's nanofluidic chip could cut DNA sequencing costs dramatically.



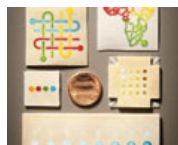
Racetrack Memory

Stuart Parkin is using nanowires to create an ultradense memory chip.



Biological Machines

Michel Maharbiz's novel interfaces between machines and living systems could give rise to a new generation of cyborg devices.



Paper Diagnostics

George Whitesides has created a cheap, easy-to-use diagnostic test out of paper.



Liquid Battery

Donald Sadoway conceived of a novel battery that could allow cities to run on solar power at night.



Traveling-Wave Reactor

A new reactor design could make nuclear power safer and cheaper, says John Gilleland.



Nanopiezoelectronics

Zhong Lin Wang thinks piezoelectric nanowires could power implantable medical devices and serve as tiny sensors.



HashCache

Vivek Pai's new method for storing Web content could make Internet access more affordable around the world.



Software-Defined Networking

Nick McKeown believes that remotely controlling network hardware with software can bring the Internet up to speed.

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10 BREAKTHROUGH TECHNOLOGIES

2008

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Year:



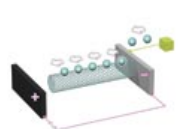
Modeling Surprise

Combining massive quantities of data, insights into human psychology, and machine learning can help manage surprising events, says Eric Horvitz.



Probabilistic Chips

Krishna Palem thinks a little uncertainty in chips could extend battery life in mobile devices--and maybe the duration of Moore's Law, too.



NanoRadio

Alex Zettl's tiny radios, built from nanotubes, could improve everything from cell phones to medical diagnostics.



Wireless Power

Physicist Marin Soljacic is working toward a world of wireless electricity.



Atomic Magnetometers

John Kitching's tiny magnetic-field sensors will take MRI where it's never gone before.



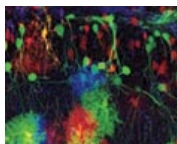
Offline Web Applications

Adobe's Kevin Lynch believes that computing applications will become more powerful when they take advantage of the browser and the desktop.



Graphene Transistors

A new form of carbon being pioneered by Walter de Heer of Georgia Tech could lead to speedy, compact computer processors.



Connectomics

Jeff Lichtman hopes to elucidate brain development and disease with new technologies that illuminate the web of neural circuits.



Reality Mining

Sandy Pentland is using data gathered by cell phones to learn about human behavior.



Cellulolytic Enzymes

Frances Arnold is designing better enzymes for making biofuels from cellulose.

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10 BREAKTHROUGH TECHNOLOGIES

2007

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Year: 2007



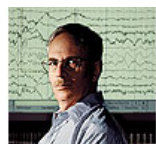
Peering into Video's Future
The Internet is about to drown in digital video. Hui Zhang thinks peer-to-peer networks could come to the rescue.



Nanocharging Solar
Arthur Nozik believes quantum-dot solar power could boost output in cheap photovoltaics.



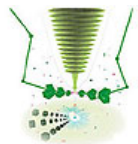
Invisible Revolution
Artificially structured metamaterials could transform telecommunications, data storage, and even solar energy, says David R. Smith.



Personalized Medical Monitors
John Gutttag says using computers to automate some diagnostics could make medicine more personal.



Single-Cell Analysis
Norman Dovichi believes that detecting minute differences between individual cells could improve medical tests and treatments.



A New Focus for Light
Kenneth Crozier and Federico Capasso have created light-focusing optical antennas that could lead to DVDs that hold hundreds of movies.



Neuron Control
Karl Deisseroth's genetically engineered "light switch," which lets scientists turn selected parts of the brain on and off, may help improve treatments for depression and

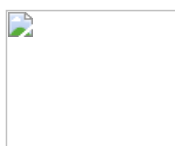
other disorders.



Nanohealing
Tiny fibers will save lives by stopping bleeding and aiding recovery from brain injury, says Rutledge Ellis-Behnke.



Digital Imaging, Reimagined
Richard Baraniuk and Kevin Kelly believe compressive sensing could help devices such as cameras and medical scanners capture images more efficiently.



Augmented Reality
Markus Kähäri wants to superimpose digital information on the real world.

Past 10 Breakthrough Technologies Lists:

2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2001



10 BREAKTHROUGH TECHNOLOGIES

2006

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Year: 2006

Nanomedicine

James Baker designs nanoparticles to guide drugs directly into cancer cells, which could lead to far safer treatments.

Nanobiomechanics

Measuring the tiny forces acting on cells, Subra Suresh believes, could produce fresh understanding of diseases.

Epigenetics

Alexander Olek has developed tests to detect cancer early by measuring its subtle DNA changes.

Comparative Interactomics

By creating maps of the body's complex molecular interactions, Trey Ideker is providing new ways to find drugs.

Diffusion Tensor Imaging

Kelvin Lim is using a new brain-imaging method to understand schizophrenia.

Cognitive Radio

To avoid future wireless traffic jams, Heather "Haitao" Zheng is finding ways to exploit unused radio spectrum.

Pervasive Wireless

Can't all our wireless gadgets just get along? It's a question that Dipankar Raychaudhuri is trying to answer.

Universal Authentication

Leading the development of a privacy-protecting online ID system, Scott Cantor is hoping for a safer Internet.

Nuclear Reprogramming

Hoping to resolve the embryonic-stem-cell debate, Markus Grompe envisions a more ethical way to derive the cells.

Stretchable Silicon

By teaching silicon new tricks, John Rogers is reinventing the way we use electronics.

Past 10 Breakthrough Technologies Lists:

[2014](#) | [2013](#) | [2012](#) | [2011](#) | [2010](#) | [2009](#) | [2008](#) | [2007](#) | [2006](#) | [2005](#) | [2004](#) | [2003](#) | [2001](#)



FEATURED STORY // COMPUTING

10 Emerging Technologies

Of the numerous technologies now in gestation at companies and universities, we have chosen 10 that we think will make particularly big splashes. They range from bacterial factories to silicon photonics to quantum wires and any one of them could change your world.

TECHNOLOGY REVIEW

May 2005

Airborne Networks

Quantum Wires

Silicon Photonics

Metabolomics

Magnetic-Resonance Force Microscopy

Universal Memory

Bacterial Factories

Enviromatics

Cell-Phone Viruses

Biomechatronics

Of the numerous technologies now in gestation at companies and universities, we have chosen 10 that we think will make particularly big splashes. They're raw, but they'll transform the Internet, computing, medicine, energy, nanotechnology, and more.

Airborne Networks

AVIATION An Internet in the sky could let planes fly safely without ground controllers. By David Talbot

Of the numerous technologies now in gestation at companies and universities, we have chosen 10 that we think will make particularly big splashes. They're raw, but they'll transform the Internet, computing, medicine, energy, nanotechnology, and more.

The technology that underpins the air traffic control system hasn't changed much in a half-century. Planes still depend on elaborate ground-based radar systems, plus thousands of people who watch blips on screens and issue verbal instructions, for takeoffs, landings, and course changes. The system is expensive, hard to scale up, and prone to delays when storms strike.

An entirely different approach is possible. Each plane could continually transmit its identity, precise location, speed, and heading to other planes in the sky via an airborne network. Software would then take over, coordinating the system by issuing instructions to pilots on how to stay separated, optimize routes, avoid bad weather, and execute precise landings in poor visibility.

Advertisement

In the near term, such technology could save travelers time and might reduce fuel consumption. Long term, it could revolutionize air travel by enabling more planes to fill the sky without the addition of infrastructure and staff. Vastly greater numbers of small planes could zip in and out



FEATURED STORY

10 Emerging Technologies That Will Change Your World

Technology Review unveils its annual selection of hot new technologies about to affect our lives in revolutionary ways-and profiles the innovators behind them.

TECHNOLOGY REVIEW

February 2004

With new technologies constantly being invented in universities and companies across the globe, guessing which ones will transform computing, medicine, communication, and our energy infrastructure is always a challenge. Nonetheless, *Technology Review's* editors are willing to bet that the 10 emerging technologies highlighted in this special package will affect our lives and work in revolutionary ways-whether next year or next decade. For each, we've identified a researcher whose ideas and efforts both epitomize and reinvent his or her field. The following snapshots of the innovators and their work provide a glimpse of the future these evolving technologies may provide.

10 Emerging Technologies That Will Change Your World

Universal Translation

Synthetic Biology

Nanowires

T-Rays

Distributed Storage

RNAi Interference

Power Grid Control

Microfluidic Optical Fibers

Bayesian Machine Learning

Personal Genomics

[Next Page »](#)

Page 1 2 3 4 5 6 7 8 9 10 11

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T-Rays from Superconductors

*A device from Argonne
National Lab takes a fresh
approach to generating t-
rays.*

Don Monroe

of thousands of small airfields (there are 5,400 in the U.S. alone), even those with no radar at all. "The biggest holdback to the number of airplanes that can be in the sky is that air traffic controllers are separating aircraft by hand," says Sally Johnson, an aerospace engineer at NASA's Langley Research Center. "Until you get away from that paradigm, we are at the limits of what you can do."

As a practical matter, airborne networks that rely on software and cockpit computers rather than humans to issue instructions are still decades away. But in June, NASA plans

to demonstrate a prototype of such an automated system at a small airport in Danville, VA. A computer at a ground station near the airport will receive data from multiple planes and give the pilots their initial holding fixes, then tell them what planes they're following and where to go if they miss their approaches. In the planes, cockpit displays will show pilots where the other planes are, and a computer will give them instructions that guide their trajectories.

Future systems might go further: planes would communicate not just via a computer on the ground (or via satellite) but directly with each other, relaying information from other planes in an Internet-like fashion. This radical advance in airborne networking could come from research funded by the Pentagon -- the midwife of today's terrestrial Internet. The vision is that not only navigational data but information about targets, real-time intelligence, and bombing results would flow freely among manned and unmanned military planes, to vehicles on the ground, and up and down chains of command. "There is a terrestrial backbone of hardwired connections, and there will be a space backbone between satellites. What we are talking about adding, for aircraft, is an equivalent third backbone in the sky," says Dave Kenyon, division chief of the Technical Architectures Division at the U.S. Air Force Electronic Systems Center in Bedford, MA.

The U.S. Air Force is beginning to define the architecture of an airborne network and hopes to begin actively developing and testing the network itself between 2008 and 2012, Kenyon says. Taken together, the military research and the related air traffic control research into airborne communications networks could change how we travel in the decades to come.

[Next Page »](#)

Page 1 2 3 4 5 6 7 8 9 10

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The Neatest Nanotech of 2005

Technology Review picks five important advances in nanotechnology and materials science in 2005 -- and one policy issue that could decide the future of the entire field.

Kevin Bullis

Smart Fibers

Optical fibers with embedded semiconductor circuits could save lives in surgery

Kevin Bullis



10 BREAKTHROUGH TECHNOLOGIES

2003

FEATURED STORY

10 Emerging Technologies That Will Change the World

Technology Review identifies the developments that will dramatically affect the way we live and work-and profiles the leading innovators behind them.

TECHNOLOGY REVIEW

February 2003

In labs around the world, researchers are busy creating technologies that will change the way we conduct business and live our lives. These are not the latest crop of gadgets and gizmos: they are completely new technologies that could soon transform computing, medicine, manufacturing, transportation, and our energy infrastructure. Nurturing the people and the culture needed to make the birth of such technological ideas possible is a messy endeavor, as MIT Media Lab cofounder Nicholas Negroponte explains in *Creating a Culture of Ideas*. But in this special section, *Technology Review's* editors have identified 10 emerging technologies that we predict will have a tremendous influence in the near future. For each, we've chosen a researcher or research team whose work and vision is driving the field. The profiles, on the following pages, offer a sneak preview of the technology world in the years and decades to come.

[Next Page »](#)

Page 1 2 3 4 5 6 7 8 9 10 11

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Nano Printing Goes Large

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Katherine Bourzac

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A new biomaterial could improve knee-cartilage repair surgery.

Alexandra M. Goho

Drawing Circuits with Nano Pens

Cheap arrays of polymer pens can draw complex nanopatterns.

Katherine Bourzac



FEATURED STORY

Emerging Technologies That Will Change the World

Ten emerging technologies that will change the world.

THE EDITORS

Monday, January 1, 2001

What if you had a crystal ball that foretold the future of technology? Imagine, for example, if you had known in 1990 just how big the Internet was going to be 10 years hence. Sorry, that crystal ball doesn't exist. But in this special issue of *Technology Review*, we offer you the next best thing: the educated predictions of our editors (made in consultation with some of technology's top experts). We have chosen 10 emerging areas of technology that will soon have a profound impact on the economy and on how we live and work. These advances span information technology, biotechnology and nanotechnology-the core of *TR* coverage in every issue. All of these areas merit special attention in the decade to come. In each area we've chosen to highlight one innovator who exemplifies the potential and promise of the field. Keep this issue around and see how well our predictions hold up-even without the aid of that crystal ball.

Brain-Machine Interface | Flexible Transistors | Data Mining | Digital Rights Management |
Biometrics | Natural Language Processing | Microphotonics | Untangling Code | Robot Design |
Microfluidics