



# The Innovation Crossroads

**The rest of the world is catching up with the United States in producing innovative products. Can America get its mojo back?**

**A Special Report**

One of the nation's most troubling economic developments in the past few years had nothing to do with Lehman Brothers, the housing market, or government bailouts. Hardly anyone noticed or lamented it. That's probably because it came in 2008, while Washington's eyes were trained north to Wall Street and not south to the edge of Old Town in Alexandria, Va., where the federal government keeps tabs on the pace of innovation.

In Alexandria, in 2008, the U.S. Patent and Trademark Office issued 185,244 patents. For

the first time, more than half of them went to inventors outside the United States. That tipping point was the culmination of a rapid narrowing of the United States' much-prized innovation lead over the rest of the world, and it wasn't a fluke. Foreign-origin patents outnumbered U.S.-origin patents in 2009 and 2010, too. Back in 2000, by contrast, domestic patents held a 55 percent to 45 percent advantage over foreign ones.

The recent numbers signal a stunning change in a critical, but often overlooked, barometer of economic health. Patents aren't simply the province of garage-shop scientists building better mousetraps. They're perhaps

the best measure we have of how effectively an economy is producing new and marketable ideas that could grow into businesses, perhaps even industries, to create jobs and spark economic growth. A landmark study by the Federal Reserve Bank of Cleveland in 2006 found that the level of innovation, measured by patents per capita, was the most important factor in determining which state economies had grown the fastest over the previous 75 years.

On an international scale, it's difficult to overstate the role of homegrown innovation in vaulting the U.S. to the top perch in the global economy and keeping it there. The Commerce Department estimates that tech-

nological innovation has spurred 75 percent of America's growth since World War II. Officials from the world's second-largest economy, China, openly marvel at the yawning gap they face in trying to catch the United States in patent production.

They are catching up, though, along with the rest of the world. In 2000, the United States issued about 700 patents to inventors from China (including Hong Kong), only slightly more than went to inventors in New Hampshire. Last year, the Chinese number was up to about 4,000, or slightly less than New Jersey's. America's other main innovation rivals—including Japan, Germany, and South Korea—also gained ground.

If American innovation is not yet in crisis, experts say, it is at least at a crossroads, struggling to find new footing in a global competition that grows tougher by the day. The very nature of innovation is shifting, and the role of government in fostering it is up for intense debate in Washington.

"We're still the leader" in global innovation, says Mark Muro, who directs the Metropolitan Policy Program at the Brookings Institution and writes frequently on innovation policy, "but there are some questions about the future. It's a moment of uncertainty. The past model worked fairly well in a pretty undemanding environment.... Retaining our mojo here is going to challenge us to reexamine some of the models. We can drift along with the same model, and we'll get some decent results, but the competition is much stiffer."

The next great leaps in innovation, Muro and others say, will require government and the private sector to collaborate more creatively, to focus on scaling up from laboratory projects to mass-production lines that can sustain millions of jobs. In the slow recovery from the financial crisis, innovators may need financing boosts from government. They will also, unquestionably, and in the tradition of great American innovations such as air travel and the Internet, require a continued focus on improving consumers' quality of life.

The experts assembled by *National Journal* for this issue all write about innovations that could catalyze job creation, it's true. But their selections also share that theme of improving the basic quality of life: Robert Atkinson's 4G wireless networks, empowering repair technicians to instantly spot bridge weaknesses, firefighters to see the inside of a burning building before they en-

ter it, and commuters to find and rent bikes; Ceci Connolly's "Doc-in-a-Phone" marriage of medical and cellular technology, detecting warnings of a heart attack or a diabetic coma in time for doctors to intervene; Ronald Klain's congestion-unclogging bullet trains; Simon J. Tripp's genomic leaps forward in feeding the world, fighting disease, and yielding an advanced generation of biofuels; and Arun Majumdar's grand energy independence quest to produce affordable electricity from the sun.

American researchers are hard at work in all those areas. American policymakers have work to do to support them. The global innovation challenge feels a lot like Olympic basketball: The days of U.S. blowouts are over. The world is catching up. The game is on, and growth and jobs are the prizes. ■

*Jim Tankersley*

## George Jetson or Ricky Ricardo? By Ronald Klain

As many commentators have noted—most recently, Matt Ridley in a thoughtful essay in *The Wall Street Journal* last month—the pace of innovation in transportation has lagged behind virtually every other sector in the economy.

A personal perspective illustrates the point. This year, I will turn 50, and my daugh-

ter turned 20. Compared with my youth, the way she cooks (microwave ovens); shops (from a global online marketplace); communicates (smartphone, text, e-mail); copes with farsightedness (laser surgery); watches movies (streamed on an iPad); and so much more has changed utterly. But when I travel to New York City to see her, I have the same four options (internal-combustion car; internal-combustion bus; train from Union Station; plane from Reagan Washington National Airport) that existed decades ago—and the travel time is virtually unchanged. In 1960s pop-culture terms, when I Skype with her, I feel like George Jetson. But when I travel to see her, I'm stuck doing it the way that Ricky Ricardo did.

Yet this may be about to change, with vast economic consequences—a boon to the U.S. economy that will create jobs and reduce pollution at the same time.

On the immediate horizon is the explosive growth in electrical vehicles—not just cars but also trucks and buses—and in the related electric-battery industry. Thanks in part to the push given these innovations by the Obama administration, the long-awaited technologies are finally coming to market. The United States is on a path under President Obama to go from producing just 2 percent of the world's batteries to 40 percent. This soaring growth means a new generation of manufacturing jobs, concentrated in the hard-hit Midwestern states but not limited there: Start-ups will soon be employing workers to build innovative electric cars on assembly lines spread across the U.S., from Delaware to California.



**Taking off?** Low-cost private planes.

PHOTOS: (PREVIOUS PAGE) ISTOCKPHOTO; GETTY IMAGES/JOE RAEDLE





There's an app for that: Think Zipcar for bikes.

High-speed rail is a second transportation technology that is moving from the planning stage to reality. Yes, these superfast trains were a political lightning rod in the 2010 elections, but their job-creating potential—in construction of infrastructure and in manufacturing the trains—should spur a consensus to build “bullet trains” in California, Florida, and perhaps even the Northeast corridor; the latter could reduce the train trip from D.C. to New York City to 90 minutes or less and boost economic growth by easing the flow of people, goods, and services in our most congested economic corridor.

Finally, there are the more-exotic transportation options, both known and unknown. Google recently demonstrated a driverless car—similar to the robot-driven taxis in science-fiction films—and has even won legal approval in Nevada to allow them on the road. The financial crisis of 2008 wiped out a nascent “very light jet” industry of low-cost private planes, but American-made “entry-level jets” are emerging in its place. Reports even suggest that personal jet packs may hit the market in the next year. All of these new transportation options will create jobs—and only time will tell what other innovations will hit our roads and skies before the end of the decade.

Americans of 2011 communicate, cook, shop, and work like the Jetsons—and while

George’s flying car is still be off in the future, transportation innovation is set to drive economic progress and job growth in the years ahead. ■

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## The 4G Jobs Revolution By Robert Atkinson

Big job-creating innovations are the result of “innovation platforms” that enable entrepreneurs and companies to build new devices, networks, and applications. In the 1990s, the new platform was the Internet. Businesses invested billions of dollars and created millions of jobs, even after accounting for the dot-com bust. Today’s next big job-creating innovation platform is the 4G mobile Internet.

We’ve come a long way since car phones were in car trunks. Today, 5 billion smartphones and other mobile devices have more computing power than the 1980s supercomputers. But over the next five years, the mobile economy will rise to a whole new level

as 4G mobile broadband comes on the scene with speeds equaling or exceeding today’s wired speeds and as hundreds of millions of people adopt smart mobile devices, from tablets to smartphones to e-book readers. The result will be an array of new applications, services, and business models that will create millions of U.S. jobs and power America’s growth.

Let’s take one example. In the past two years, bike-sharing programs that enable people to rent bicycles by the hour have sprung up in many cities. Think Zipcar for bikes. But without the mobile Internet, this model couldn’t work. Wireless data links connect the bike racks to a bike-tracking and billing database, and smartphone apps show riders where rental stations are and how many bikes are available.

This mobile platform—the 4G network, easy-to-use devices, and great apps—opens the door to new applications and business models. San Carlos, Calif., is using mobile networks to send construction schematics to firefighters en route to a blaze. Amtrak conductors use mobile devices to read tickets. The owners of “smart homes” can use their mobile devices to remotely control the lights, adjust the air conditioner, and program the digital video recorder. Obstetricians can use the AirStrip OB system to monitor the fetal heartbeat and maternal contraction patterns of

their hospital delivery-room patients directly from their smartphones. Even our transportation infrastructure is getting smart: A new bridge in Minneapolis is equipped with wireless sensors that enable engineers to remotely monitor its condition. And the mobile Internet is allowing new implementations of augmented reality to digitally enhance our interaction with the physical world. Individuals can point the camera of their smartphones at a building and instantly see relevant data, such as restaurant reviews or real-estate listings. In five years, we will likely look back and be amazed at what new mobile Internet has wrought.

As the new platform powers growth, the federal government can help or hurt. Congress and the Federal Communications Commission should transfer licenses from inefficient, over-the-air digital television to mobile wireless through an auction and use some of the money generated to support the expansion of 4G networks throughout most geographic areas. Government should also be a first adopter, transforming its operations through next-generation mobile broadband. And finally, policymakers should avoid enacting privacy regulations that would stifle the development of mobile-broadband applications. ■

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## The Genomics Promise

### By Simon J. Tripp

Our ability to understand, harness, and manipulate life has experienced a dramatic leap forward. Modern molecular biology, genomics, and post-genomic sciences now form an innovation platform using sustainable biological resources.

The pace of technological advancement in gene sequencing has been stunning, with sequencing speeds more than doubling each year (a pace exceeding even that of semiconductor processing). As a result, we now see machines, such as Life Technologies' Ion Torrent, that sit on a desktop and make sequencing feasible at comparatively low cost and with unprecedented ease. The first human-genome sequencing cost \$3.8 billion; currently, it can be done in a day for less than \$3,000. Obviously, the tools and technologies that power genomic analysis (an industry whose largest footprint is in the United States) are contributing to innovation and economic development; but more important, low-cost, high-output sequencing is driving a revolution in



the application of genomics to major markets. Among them:

- **Agriculture and agbioscience.** Genomics is used to develop genetically modified crops with enhanced input traits (including water- and nitrogen-use efficiency, pesticide tolerance, disease resistance) and output traits (such as enhanced nutrition content or easier downstream processability for food or bioenergy applications). Likewise, genomics empowers improvements in livestock health and production. Using domestic resources, agbioscience represents an opportunity for job development nationwide, in both rural and urban America.

- **Environmental applications.** Genetically engineered microbes can be used to capture toxic substances, heavy metals, oil, and other pollutants. Also, organisms that are able to survive in radioactive environments, or can withstand extreme heat, cold, or pH levels, create substantial opportunities for novel applications.

- **Industrial biotechnological processes.** Engineered organisms and enzymes drive production of biobased products, such as food, chemicals, and advanced materials, as well as biofuels.

- **Human and veterinary medicine.** Genomics is identifying targets for new therapeutics, producing high-accuracy diagnostics, and bringing gene therapy and regenerative medicine to clinical reality. Genomics is paving the way to a new paradigm of personalized medicine, or "P4," that is predictive, preventive, personalized, and participatory—medicine with increased efficacy and reduced side effects.

The range of novel products likely to be developed on the back of genomic advancements will be very broad, and thus the opportunities for business development and job

creation will be substantial. Battelle Memorial Institute's recent study of the effects of the Human Genome Project found that the U.S. genomics and genomics-enabled business sector recorded \$22.6 billion in sales in 2010 and directly employed more than 51,600 workers. The sector's overall impact on the economy (direct and indirect) is estimated to be far larger: \$67.1 billion in output and more than 310,000 jobs. And this is just the leading edge of a growing wave. Job generation will occur in advanced biofuels production (in which genomics is key); value-added bioprocessing industries (for chemicals and materials); advanced food and nutrition products; environmental technologies; and biomedical applications. Modern genomics has emerged as a central driver of U.S. technology-based economic opportunity.

From a policy perspective, it is notable that the emergence of the genomics-empowered industry is both a public- and private-investment success story. Fundamental advances in genomics were propelled by the federal government's financing of the Human Genome Project and by subsequent follow-on government-funded "omics" projects. These government-sponsored projects provided the foundation for further private-sector investment to leverage and build on scientific advancements. Industry leaders and observers acknowledge that the genomics industry's growth owes much to the foresight shown by Washington in backing the Human Genome Project.

Today, five key forces are driving demand for genomics-empowered innovations: 1) A global imperative to increase agricultural productivity and food security (to feed a population that is expected to expand by 2.3 billion between now and 2030); 2) An ongoing global demand for new medicines to combat exist-



ing and emerging diseases; 3) An imperative to use sustainable resources to help preserve our environment and combat climate change; 4) A strategic need to replace unsustainable, imported fossil resources with homegrown, renewable biobased products; and 5) A need to grow our economy through novel, high-value products and services that will support high-wage, family-sustaining jobs. Genomics and associated tools and technologies provide the promise of solutions to each of these grand challenges. As such, there should be little doubt that the genomics-empowered modification, engineering, and utilization of biological resources is, and will continue to be, a key strategic driver of U.S. economic competitiveness and growth. ■

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## Doc-in-a-Phone By Ceci Connolly

Reporters don't like making predictions. And even though I've left journalism, the prediction-aversion gene remains dominant. So when *National Journal* asked what I thought would be the next decade's great medical innovation, I started reporting.

The thrilling news is that the health care field is teeming with possibility. In the developing world, seemingly simple oral-rehydration therapy for children is an innovation

that saves lives and money. Researchers tell us that breakthroughs in molecular science could lead to an era of personalized medicine in which the body's own materials replicate, regenerate, and repair it.

But what I heard about the most was the potential explosion of mobile health, the marriage of medical care and cell-phone technology.

Think of it as Doc-in-a-Phone.

Mobile networks today cover 98 percent of the world's population. Across the globe, cell phones are used to conduct banking, monitor elections, and teach classes. The technology has broken geographic, socioeconomic, political, and even generational barriers.

Early efforts in mobile health care, known as mHealth, have focused on simple information transfers. A Mexican cell-phone company is offering 24/7 medical consultations and deep discounts on items such as lab work and medications for a monthly fee of about \$5. More than 1.2 million households subscribe to the service, called MedicalHome.

In the United States, mobile communications already deliver medication alerts and appointment reminders. A clinical trial was just launched for patients to track overactive-bladder symptoms with the help of a smartphone.

The next step in the mHealth journey involves taking standard tools of the health care trade—stethoscopes, glucometers, and electrocardiogram machines—and connecting them wirelessly to a data hub or medical command center. This two-way communications ability offers the hope of better compliance, earlier detection of warning signs, and faster interventions.

Imagine a heart patient who has a tiny

chip on her chest. Readings it sends to a nursing station detect an irregularity. The system alerts the patient to go to the emergency room, drastically improving her health prospects and reducing care costs.

But to make a truly significant impact, this burgeoning field will need to address fundamental problems such as chronic conditions, physician shortages, and the need for robust outcome measurement. In the United States alone, nearly 26 million people live with diabetes, a disease that exacts an enormous toll on patients, productivity, and budgets. Perhaps mHealth can finally help patients and doctors coordinate a real-time, personalized drug, diet, and exercise regimen.

Success will require strategic partnerships. Physicians may love the idea of getting radiology results on their smartphones, but they might be much more skeptical about dispensing medical advice without an in-person examination. The pending demise of Google Health illustrates that high-tech/medical partnerships are far from a sure thing.

On the other hand, a 2009 McKinsey survey of 3,000 people in Brazil, China, Germany, India, South Africa, and the United States found that up to one-third of respondents indicated some willingness to pay for mHealth services such as drug delivery, physician phone consultations, and remote monitoring with alerts.

In the decade ahead, the ubiquitous mobile device has the potential to help drive down skyrocketing medical costs, improve access, tailor therapies, and improve quality of life. Consumer appetite will play a major role in the future of mHealth. But even more important, the medical community, technology companies, and regulators will have to overcome their differences if Doc-in-a-Phone is to deliver on its most ambitious promises. ■

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Can you see me now? Using a smartphone for a medical diagnosis.

## Catalyzing Energy Innovations By Arun Majumdar

With the flick of a switch, we turn on the lights in our homes. With the turn of a key, we start our car engines and drive our children to school. We fly in airplanes and cross the continent



**Project SunShot:** Finding cheaper ways to produce solar energy.

in less than a day. People in the 1800s could never have imagined this lifestyle.

If we stop for a moment and think about how our lives have changed so dramatically, we will find an unbelievable story of 100 years of American innovations that changed the world and the public-private partnerships that made them possible.

For example, although the Wright brothers made Americans first in flight in 1903 with their revolutionary airplane, the United States soon lost its technological leadership to Europe. Fortunately, federal research and regulatory support through the mid-1900s helped re-propel the U.S. aviation industry ahead of its international competitors. In the 1940s and '50s, government funds helped General Electric develop the military's first jet engine, which enabled our commercial-aviation industry to take off.

The American government's support for technology helped make these innovations—and the American businesses based on them—possible. These advancements have not only changed lives around the world but also led to jobs and economic prosperity at home.

Yet today, we find that our children's futures are at risk. We import approximately 50 percent of the oil used in the United States and pay about \$1 billion a day for this resource. Oil is the overwhelming option for fueling

our cars, trucks, and planes, making us vulnerable to geopolitical and price uncertainties. This poses not only a national-security risk but an economic one as well. Many developing economies, such as China and India, face the same problem. The need for sustainable growth of the world economy warrants another era of energy innovations, which undeniably offers the biggest business opportunity of the 21st century.

Can we use our American ingenuity and the scientific infrastructure of our universities, national laboratories, and businesses to create a new industrial revolution and deliver not one but multiple technological breakthroughs in energy? President Obama and Congress authorized the Energy Department's Advanced Research Projects Agency—Energy to ensure our country's continued technological leadership in the 21st century. As the agency's director, I have been exposed to many innovative and inspiring technological breakthroughs. Two examples that could change the world are affordable electric cars and electricity from sunlight.

Electric cars will become competitive if they have a longer range and a lower life-cycle cost than cars based on gasoline. That requires batteries with double the energy density and one-third the cost of today's state-of-the-art lithium-ion battery. The Advanced Research Projects Agency sponsored a competition

among scientists and engineers to invent this battery of the future. What we are witnessing is a new era of innovations—an all-electron battery, a magnesium-ion battery, a lithium-sulfur battery, and the whole class of metal-air batteries. We don't know which one will solve the problem, but we must try different ideas and approaches because if even one succeeds, it will change the world by producing affordable electric cars.

Although there is more than enough sunlight to power the world, electricity produced from the sun is simply too expensive—it costs three to six times more than electricity produced from fossil fuels. The Advanced Research Projects Agency, along with other Energy Department offices, established the SunShot Initiative to find innovative ways within this decade to produce electricity from sunlight that costs less than electricity from fossil fuels. Doing so will ensure that the U.S. maintains its technological lead and provides a sustainable source of affordable electricity for the planet.

I firmly believe that America has the innate ability to create a new era of energy-technology innovations, and we are already on our way. Stay tuned. ■

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