

SCIENTIFIC AMERICAN



The ethical and policy ramifications of deploying science and technology in the service of society hold the same importance as the act of invention itself. Getting antiretroviral treatments to HIV/AIDS patients in sub-Saharan Africa. Ensuring that the world's largest chip manufacturer takes every possible step to reduce the company's environmental footprint. Lending the currency of one's celebrity (as well as cold, hard cash) to a global campaign to abolish smoking.

Leadership in these realms requires vision and imagination that transcends mere engineering ingenuity. This year's SCIENTIFIC AMERICAN 10 pays tribute to the exceptional foresight and accomplishment of a select group whose achievements, particularly during the past year, stand out from those of their peers. The 10 winners have demonstrated that establishing a public health program or running a green business requires more than administrative efficiency and good public relations. Bringing creativity to bear in overcoming institutional and bureaucratic imped-

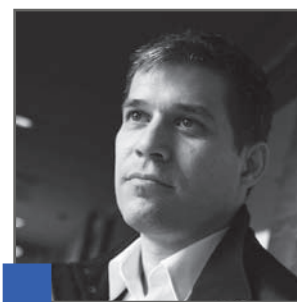
iments to adoption of not just new technology but innovative procedural methods is crucial for improving health care and the environment.

One winner helped to build an incubator for newborns that could be fashioned from car parts so that it could be easily repaired in rural areas of developing countries. Another realized that an innovative infrastructure for recharging and swapping out large batteries might offer a way to route around the technological obstacles that have held up commercial electric cars. Pure technological inspiration is also honored in the form of a practical means of taking a few skin cells from, say, a person's arm and converting them to the equivalent of embryonic stem cells.

This combination of leadership and inventiveness exhibited among the SCIENTIFIC AMERICAN winners for 2009 serves as a template for how we might consider tackling the most seemingly intractable problems of resource depletion, inadequate health care and desperate educational need.

—*The Editors*

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COURTESY OF THE WHITE HOUSE (Obama)



TODD BRADY

CORPORATE ENVIRONMENTAL MANAGER
Intel, SANTA CLARA, CALIF.

Intel's first green building, a design center, is set to open this year in Haifa, Israel.

A chip company makes expansion of its environmental footprint a priority

A multibillion-dollar technology company such as Intel could choose many ways to go green. It could build more energy-efficient production plants or eliminate toxic chemicals from its products. It could minimize greenhouse gas emissions or recycle its waste. It could buy wind power and renewable energy credits. Or with the help of a passionate corporate environmental manager like Todd Brady, it could do all of the above.

Brady, who has been with Intel since 1995, has helped the company earn its reputation as a world corporate environmental leader. He played a large part in the development of Intel's first green building, due to open this year, which carries the esteemed Leadership in Energy and Environmental Design (LEED) certification. This development design center in Haifa, Israel, recycles waste heat captured from computers in the data center and uses

it to warm the space. Three quarters of its occupied office space is lit completely by sunlight coming in through large windows.

Brady was also a driver in the company's bold decision to reduce energy consumption by 4 percent and greenhouse gas emissions by 30 percent by 2010. Since 2001 Intel has saved more than 500 million kilowatt-hours of energy, enough to power more than 50,000 homes.

It has also conserved nine billion gallons of freshwater, reduced its global-warming footprint by removing 50,000 automobiles from the road, and stopped using lead and halogen in its processors. And in 2008 the U.S. Environmental Protection Agency announced that Intel had become the single largest corporate purchaser of renewable energy certificates in the U.S.—thanks, again, to Brady's stewardship. —Melinda Wenner

COURTESY OF INTEL

SHAI AGASSI

FOUNDER AND CHIEF EXECUTIVE
Better Place, PALO ALTO, CALIF.

A wonderfully simple recharging scheme may ensure a future for electric vehicles

In our impatient economy, electric cars simply haven't been able to keep up. Sure the Tesla Roadster is fast and trendy, but a luxury price and a charge time of about three hours curb its appeal. Chevrolet's Volt, scheduled for 2010, though more accessible, can venture only 40 miles before petering out. Shai Agassi, an auto industry newcomer, thinks the prospect of a world without oil requires a more expansive vision. The former software executive is methodically assembling an entirely new automobile infrastructure: an electric recharge grid fueled by solar and wind energy. Drivers would buy miles on a subscription plan, then swap out discharged batteries for fresh ones at conveniently located exchange stations. In California, for instance, "switching stations" 30 miles apart on major freeways could cover



the state. For a short-distance top off, workers or shoppers could park and plug into a metered charging spot. An operating system in vehicle-based computers would help drivers match destinations to their battery life and recharge options.

Agassi's start-up, Better Place, launched a pilot last year in Israel, where tax incentives should bump up interest and help support a plan for mass marketing by 2011. Venture capitalists have committed \$200 million to the business; Denmark, Australia, Ontario, Hawaii and California also have signed on for their own charging networks. Renault-Nissan will supply electric cars for the deal. Eventually, Agassi anticipates, lithium-ion batteries will extend mileage, and standardized sizes will enable the network to serve multiple car models. By weaving technology, policy and practical road service together, Agassi's system could make electric cars a reality.

—Sally Lehrman



Electric cars will get a boost from battery-switching stations.



WAFAA EL-SADR

CHIEF
Infectious Disease Division, Harlem Hospital Center, NEW YORK CITY

The physician leads a multipronged public health campaign to fight the scourge of HIV

A staggering third of all HIV/AIDS patients suffer from tuberculosis, and the infection ultimately kills half of those with both diseases. Wafaa El-Sadr has assumed a leadership role in a campaign intended to ensure that the numbers will soon start falling. El-Sadr, director of the Columbia University International Center for AIDS Care and Treatment Programs (ICAP), has recently initiated a partnership between ICAP and nearly 400 health care facilities in sub-Saharan Africa in an effort to curb the HIV/TB crisis. As of December 2008, these African centers had screened 106,000 HIV-infected people for TB and had developed a set of coordinated strategies both to treat TB and to prevent its transmission.



The Egyptian-born physician has focused on all aspects of the HIV pandemic, and her work won her an esteemed MacArthur Fellowship in 2008. After joining the Harlem Hospital Center in 1988 as chief of infectious diseases, El-Sadr pioneered a comprehensive, family-based model for HIV care that is now implemented around the world. She also led an initiative to minimize the risk of mother-to-child transmission of HIV that has helped thousands of women across eight countries.

El-Sadr has been involved in research that will ultimately guide doctors in determining the best course of HIV/AIDS therapy. From 2001 to 2006, she co-chaired the largest HIV treatment study ever conducted: Strategies for Management of Antiretroviral Therapy, or SMART. One of its main conclusions was that HIV patients live longer and healthier lives when they stay on antiretroviral therapy permanently. Now El-Sadr is working to ensure that ongoing treatments are possible: as of last year, ICAP supported one tenth of HIV/AIDS patients receiving antiretroviral treatment in sub-Saharan Africa. —Melinda Wenner

JIM WILSON/New York Times (Agassi); DAVID SILVERMAN/Getty Images (battery switching); COURTESY OF THE MACARTHUR FOUNDATION (El-Sadr); ANTHONY NUGUINA/Reuters/Corbis (AIDS ribbon)

ROBERT J. LINHARDT

PROFESSOR OF BIOCATALYSIS AND METABOLIC ENGINEERING
Rensselaer Polytechnic Institute

A chemical sleuth unravels the cause of deaths from a tainted drug

When Americans began dying in January 2008 from the effects of contaminated heparin—a complex carbohydrate that has been a key component of medical blood thinners since the 1930s—the U.S. Food and Drug Administration asked Robert J. Linhardt, who is a chemist at the Rensselaer Polytechnic Institute, to help it identify the culprit. Linhardt not only succeeded, he also devised a solution that may one day prevent such scares from occurring again.

The problem was rooted in the burgeoning demand for blood thinners: the U.S. uses 300,000 doses of heparin a day to prevent blood clots during procedures such as heart-bypass surgeries and kidney dialysis. U.S. pharmaceutical companies mainly buy heparin that has been isolated from the intestines of pigs grown on American farms, but the nation uses more heparin than it can make, so drugmakers here also have to import it.

When heparin complications began surfacing in early 2008, the FDA fingered products imported from China's Changzhou SPL Company. At that point the FDA, along with an American firm that sold Changzhou's tainted product, asked Linhardt for help. Within weeks, Linhardt and his colleagues had painstakingly separated out the heparin's components and identified the source: oversulfated chondroitin sulfate (OSCS), a chemical based on a drug used to treat osteoarthritis. The OSCS may have been added to the heparin as a cheap filler, but it ultimately killed 81 Americans by causing inflammation and dangerous blood pressure drops.

Tracing the reason for the deaths wasn't good enough for Linhardt, though—he also wanted a solution. By August he and his colleagues had announced that they had synthesized a dose of pure heparin a million times larger than any lab-made dose before it. Their secret:

using *Escherichia coli* bacteria as tiny chemical factories. And although the synthetic form is still a long way from hospital shelves, Linhardt's work represents a giant step toward a future in which heparin saves lives as it should—and never again takes them.

—Melinda Wenner



EUGENIE SCOTT

EXECUTIVE DIRECTOR
National Center for Science Education, OAKLAND, CALIF.

A champion for the teaching of evolution steps up her advocacy

Thomas Henry Huxley was the 19th-century biologist known as “Darwin’s bulldog” for his defense of the great scientist’s ideas. The 21st century has a counterpart in the woman who describes herself as “Darwin’s golden retriever.” Eugenie Scott has emerged as one of the most prominent advocates for keeping evolution an integral part of the curriculum in public schools in her role as head of the nonprofit National Center for Science Education (NCSE). Scott became executive director of NCSE in 1986, a year before the U.S. Supreme Court ruled it illegal to teach creation science in public schools in its *Edwards v. Aguillard* ruling.

Scott was a physical anthropologist at the University of Kentucky in 1980 when she became interested in so-called creationist science, which attempts to reconcile biology, geology and other disciplines with literalist interpretations of the Bible. She headed a grassroots movement in Lexington to prevent creationism from being taught in the public schools there.

In 2005 she served as a pro bono consultant in the landmark *Kitzmiller v. Dover* trial, in which Judge John Jones ruled that “intelligent design” was a form of creationism and was therefore unconstitutional to teach in public schools.

Last year Scott and the NCSE faced an uphill battle over the Academic Freedom Act in Florida, which allows educators to teach about “controversies” related to evolution. Similar legislation this year appeared to be stalled in the state legislature.

In March the Texas State Board of Education voted to drop the requirement that science classes consider the “strengths and weaknesses” of Darwin’s theories, a demand born of the campaign to peddle creationism under another name. But instead of eliminating the problem, the board voted to include wording that students should “analyze and evaluate” the theories, despite a petition from the NCSE stating that while the words were different, the intent to discredit Darwin was the same. With the ever-changing semantics of antievolutionists, Darwin’s golden retriever will have plenty more chances to act as a loyal defender of teaching evolution in the schools.

—Kate Wilcox



BILL GATES/MICHAEL BLOOMBERG

CO-CHAIR

Bill and Melinda Gates Foundation

MAYOR OF NEW YORK CITY

Celebrity heft propels a campaign to limit smoking

It is deadlier than malaria, AIDS and tuberculosis combined, felling more people annually than any other agent. And it is spreading with alarming speed, especially in developing countries. Microsoft co-founder Bill Gates teamed up last year with media magnate and politician Michael Bloomberg to battle killer tobacco with a \$375-million global antismoking initiative.

The partnership builds on a \$125-million international grants program Bloomberg started in 2006 to promote policies such as smoke-free public spaces, advertising bans, tax hikes and anti-smuggling measures. The new infusion (\$250 million from Bloomberg and \$125 million from the Bill and Melinda Gates Foundation) pays for campaigns to educate children and adults about tobacco's harms, to protect individuals against secondhand exposure and to help smokers quit. The initiative also will train tax officers and health officials to establish effective antismoking

directives. And it will monitor global tobacco use and evaluate strategies for control. Partners include the World Health Organization, the Centers for Disease Control and Prevention, and the World Lung Foundation. Although the emphasis is on cigarette-hungry Bangladesh, China, India, Indonesia and Russia, Gates also hopes to tamp down Africa's still modest appetite.

Bloomberg, a former smoker, built a reputation for antismoking crusades during his two terms as New York City mayor. The attack on tobacco is new to the Gates Foundation, best known for its assault on infectious disease. Poor to middle-income countries currently spend a mere \$20 million on antismoking campaigns—but collect \$66 billion in cigarette taxes. With this injection of funds and a well-crafted initiative, Bloomberg and Gates may well shape the political will and policies needed to help the world kick its habit.

—Sally Lehrman

CHRIS HONDROS/Getty Images



A carburetor incorporated into an indoor cookstove cuts toxic gas emissions.

BRYAN WILLSON

PROFESSOR OF MECHANICAL ENGINEERING
Colorado State University

An engineer facilitates clean energy technology for the developing world

Somewhere close to half the world's population relies on outrageously inefficient, fuel-greedy indoor stoves to prepare daily meals. The cookers pump out noxious gases such as carbon monoxide and benzene, lethally poisoning as many as 1.6 million people every year. With careful design, a simple carburetor and an insulated chamber, Bryan Willson's team at the Engines and Energy Conversion Laboratory at Colorado State University have solved the problem. Now, for just \$10 to \$40, families in India and the Philippines can buy a sleek stove that cuts emissions by 80 percent, uses less fuel and even heats food faster.

Two-stroke engines—the kind used on tens of millions of motorcycle taxis in Africa, India and the Philippines—also blacken the air with a deadly cocktail. Willson's students created a bolt-on kit that converts these engines from carbureted to direct fuel injection, slashing tailpipe emissions equivalent to about 50 modern cars with each retrofit. Envirofit, a nonprofit spin-off of Willson's lab, sells the conversion kits in the Philippines for about \$200. Granted, this is a huge investment for a taxi driver, but it is still affordable through a microloan program combined with a fat, 35 percent boost in fuel efficiency.



Willson, a mechanical engineer, has expanded his cramped, Fort Collins lab into a hothouse for clean energy inventions. But the innovation he inspires doesn't end there. By helping students and collaborators apply expertise in development economics and entrepreneurship, Willson makes sure that technical solutions reach those who need them.

—Sally Lehrman

KRISTIAN OLSON

PROGRAM LEADER

Center for Integration of Medicine and Innovative Technology, BOSTON

Simple, low-cost resuscitators and incubators can save newborns in the developing world

A few years ago Kristian Olson's wife gave birth to triplets after a difficult labor. The 38-year-old pediatrician and internist realized that if his wife had gone through childbirth in many of the places where he spends a great deal of time, the infants would not have survived. That understanding made Olson an even more ardent champion of deploying simple and inexpensive technologies that will enable newborns to survive outside the protective shelter of high-tech medical centers.



One colleague told the *Boston Globe* that Olson is "The Man" when the topic turns to lifesaving technologies for the developing world. Last year Olson and the Center for Integration of Medicine and Innovative Technology (CIMIT)—a nonprofit consortium of Boston teaching hospitals and engineering schools—moved ahead with a program to demonstrate the effectiveness of \$7 resuscitators, tubes through which a medical worker exhales into a newborn's mouth. The program started after the 2004 South Asian tsunami. Since then, about 500 midwives in Aceh, Indonesia, have been trained to use the technology.

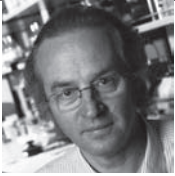
Another project Olson continues to spearhead under CIMIT's Global Health Initiative is development of an incubator built from car parts. The idea, conceived of by a former CIMIT official, is simple: expertise and parts to fix medical equipment may be lacking in rural hospitals, but the know-how to fix cars is ubiquitous. Olson headed the team that built prototypes of the incubator, proving the feasibility of one of CIMIT's goals of bringing untraditional solutions to solving the problems of poor nations.

—Gary Stix



Incubators made from car parts might one day replace the blankets used in this intensive care unit in Katmandu, Nepal.

COURTESY OF ENVIROFIT (cookstove); COURTESY OF COLORADO STATE UNIVERSITY (Willson); CENTER FOR INTEGRATION OF MEDICINE AND INNOVATIVE TECHNOLOGY (Olson); COURTESY OF DESIGN THAT MATTERS (Incubators)



ANDRAS NAGY

SENIOR INVESTIGATOR
Mount Sinai Hospital, TORONTO

A biologist discovers a practical method of making stem cells from mature cells

Federal funding for U.S. embryonic stem cell research may have the green light again, but the reversal does nothing to undermine the diligent and creative work of researchers who have, over the past eight years, developed possible alternatives. Among the most

successful is Andras Nagy, a biologist at Mount Sinai Hospital in Toronto, who has developed a novel way to convert mature cells into the functional equivalent of embryonic stem cells.

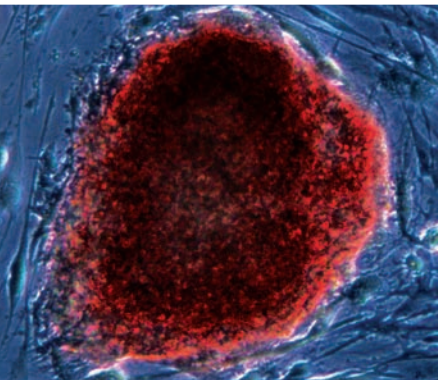
Nagy's research has come up with perhaps the most practical method to date. In 2006 two laboratories independently turned adult skin cells into stem cells that were pluripotent—or had the ability to develop into many different types of cells—simply by turning on the activity of four genes. Problem is, the viruses used to introduce the

active genes sometimes rendered the cells cancerous. In 2008 Japanese scientists announced that they had eliminated the need for viruses entirely, but their solution was horribly inefficient: when their experiments worked, they were lucky if 29 out of every million cells actually became stem cells.

In February, Nagy announced that he had a better solution. He and his colleagues had introduced the four necessary genes into mouse and human cells by way of a linear genetic construct called a transposon, which has the ability to efficiently insert itself into a cell's genome. As a bonus, genes inserted with a transposon can later be removed with the aid of an enzyme called a transposase—meaning they will not cause cancer or other untoward effects down the line.

Once Nagy added the four genes, many of the mature cells converted into stem cells—after 20 days the investigators identified up to 48 separate stem cell colonies. The cells remained pluripotent even after they removed the genes again. In effect, Nagy and his colleagues had, for the first time, created the equivalent of embryonic stem cells that were uncontroversially ethical, safe *and* efficient—a significant advance toward being able to use them in patients in a clinic.

—Melinda Wenner



Toronto researchers discovered a practical way to convert a mature skin cell into a stem cell (above).

COURTESY OF SID TABAK, Mount Sinai Hospital (Nagy); KNUIT WOLTIEN, Mount Sinai Hospital (stem cell); CHIP SOMODEVILLA, Getty Images (Obama)

BARACK OBAMA

PRESIDENT OF THE U.S.

The new chief executive begins his term by initiating a radical shift in science policy

After eight long years in exile, scientists have been enthusiastically welcomed back into the White House. In the first few months of his administration, President Barack Obama acted with remarkable speed to place science at the center of policy-making on climate change, energy, health care and research funding. He wiped away science-averse policies and appointed outstanding scientific talent—including physicists Steven Chu and John Holdren, marine ecologist Jane Lubchenco, and biomedical experts Harold Varmus and Eric Lander—to top posts.

In March, President Obama lifted the ban on federal funding for embryonic stem cell research and asked the National Institutes of Health to devise new rules. With a pledge to listen to scientists, “especially when it’s inconvenient,” he simultaneously ordered the creation of policies that would protect scientific integrity and ensure transparency in policymaking.

That same month, international climate change delegates in Bonn applauded a pledge by Todd Stern, President Obama’s special climate envoy, to “make up for lost time” and combine urgency, science and pragmatism in U.S. actions. Indeed, the president’s budget called for \$150 billion to fund research, development and technology for clean energy over 10 years, plus \$43 billion in additional research and infrastructure funding and \$20 billion in tax incentives already built into the economic stimulus plan.

When making the choice to award the president, we searched among less obvious candidates who were deserving of broader public recognition. But President Obama’s accomplishments in a matter of weeks of taking office were so extraordinary that he could not be denied. The new president’s actions have proved almost startling after the Bush administration, which was criticized for routine suppression of scientific knowledge for political purposes. But the impact of the Obama White House will likely reach far beyond such a facile comparison. The president’s unprecedented emphasis on science and technology should propel basic research, innovation, and U.S. scientific and technological competitiveness for generations to come.

—Sally Lehrman

