SCIENTIFIC AMERICAN 50

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New technologies appear all the time. Right at this moment scientists are laboring away on the Herculean task of making an artificial cell, a challenge that for the first nine tenths of the 20th century many biologists would have dismissed as an impossibility. Just as important as new invention, though, is the translation of ingenuity into practice. This year's Scientific American 50 represents a testament to pragmatism. Many of the reports that have wowed the public on advances in nanotechnology or stems cells, to name just two, have taken a big step from graduate-level research toward becoming items for purchase at Wal-Mart or routine therapies at your local hospital.

A Korean researcher gained worldwide attention by achieving a 10-fold improvement in the number of stem cell lines derived from cloned human embryos. Japanese investigators created a solar cell that both generates and stores electricity. For the fourth year, the Scientific American 50 recognizes people, teams and organizations whose recent accomplishments, whether in research, business or policymaking, demonstrate leadership in shaping both established and emerging technologies.

In naming the winners of 2005, the magazine's editors and their expert advisers identified noteworthy trends related to technology ranging from polymer memory chips to a technique for regenerating damaged heart tissue. As you will see, the awards provide evidence once again that the application of new science, business acumen and policymaking skills not only can help build new machines but also can make a substantial difference in the way we all live.

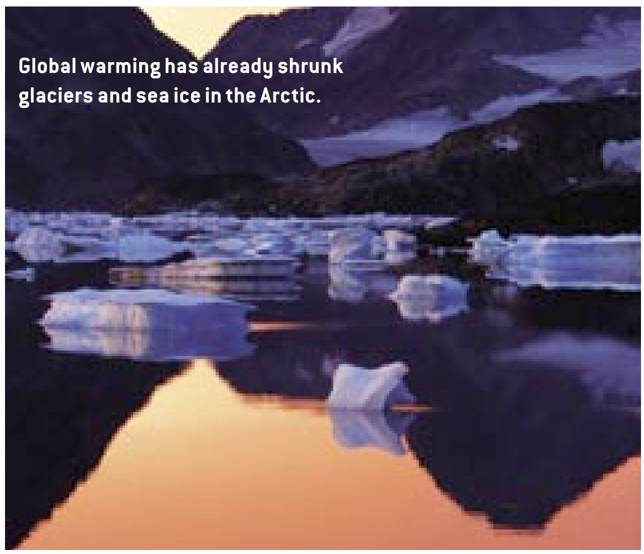
Protections for the Earth's Climate

Industry, local governments and academia look for solutions to global warming

The battle to prevent or at least slow global warming has intensified in the past year as scientists have learned more about the magnitude of the problem. One of the leading climate experts, **Inez Y. Fung**, director of the Atmospheric Sciences Center at the University of California, Berkeley, recently showed that the earth may soon lose its ability to absorb much of the greenhouse gas that is raising temperatures. The oceans and continents currently soak up about half the carbon dioxide produced by the burning of fossil fuels. In the oceans, the gas combines with water to form carbonic acid; on land, plants take in more carbon dioxide and grow faster. But computer modeling done by Fung and her colleagues indicates that these carbon sinks will become less effective as the earth continues to warm. For example, as the tropics become hotter and drier in the summer, plants will curtail their respiration of carbon dioxide to avoid water loss. Atmospheric measurements over the past decade have confirmed this effect. If the oceans and land take in less carbon dioxide, more will remain in the atmosphere and global warming could accelerate catastrophically.

Despite these warning signs, the administration of President George W. Bush has opposed ratification of the Kyoto Protocol, the international treaty mandating reductions in greenhouse gas emissions. (Signed by more than 150 nations, the treaty went into effect this past February.) But nine states in the northeastern U.S. are attempting to sidestep the federal government's opposition by taking action on their own. In 2003 the governors of Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont created the **Regional Greenhouse Gas Initiative**. Last August the group reached a preliminary agreement to freeze power plant emissions of carbon dioxide by 2009 and then reduce them by 10 percent by 2020. The plan requires approval by the state legislatures, but environmentalists are already hoping that other regions of the U.S. will follow suit. If adopted nationwide, the proposal would lower greenhouse gas emissions by roughly as much as the Kyoto Protocol would have.

Steve Howard, chief executive of the Climate Group, is tackling the global-warming problem from a different angle. Founded in 2004, the Climate Group is a coalition of corporations and state and local governments that have voluntarily committed to reducing their greenhouse gas emissions. Members include oil giant BP, drugmaker Johnson & Johnson, and Starbucks. Businesses in the Climate Group have discovered that improvements in energy efficiency can enhance profits as well as cut fossil-fuel emissions; BP, for instance, slashed its energy bills by $650 million over 10 years. "We have seen important evidence about successful emission reduction scattered here and there in the most surprising places all over the globe," Howard says. "We are working to bring all of it together so that it forms a body of evidence." —*Mark Alpert*



Global warming has already shrunk glaciers and sea ice in the Arctic.

JOHN McCONNICO *AP Photo*

A Future in Plastics

The march toward less expensive, more flexible electronics continues

Organic semiconducting materials will never replace the silicon chips in your computer, but now they are finding their way into applications ranging from flexible displays to low-cost radio-frequency identity tags, for which silicon chips are not suited. The past year has witnessed advances in both the development of specific devices and understanding of the basic physics of the materials.

On the device front, **Paul W. M. Blom** and his student **Ronald C. G. Naber** of the University of Groningen in the Netherlands and their collaborators developed an inexpensive nonvolatile memory chip out of a physically tough polymer. The working element of the device is a field-effect transistor containing a layer of ferroelectric polymer that can be switched between two states by a voltage pulse.

Similar structures have been studied before, but the Groningen device is the first to combine several desirable properties, including a long data-retention time after the power is turned off and a short programming time (it takes only a millisecond to write data to the transistor). In addition, the devices can be manufactured by depositing the various layers of the transistor out of a liquid solution, including the all-important ferroelectric layer. Large-scale industrial production should therefore be feasible using low-cost techniques such as spin-coating or printing. The work was done in collaboration with researchers at **Philips Research Eindhoven** in the Netherlands.

An organic film of phenylene vinylene molecules self-assemble into well-ordered layers that control charge flow.

Of crucial importance for the future of plastic electronics is the cultivation of a good understanding of precisely how electric currents flow in the devices. Most organic semiconductor devices suffer from numerous material defects, which dominate the behavior of moving charges and obscure efforts to understand the intrinsic properties of the material. In August 2004 a research group led by **John A. Rogers** of the University of Illinois and **Michael E. Gershenson** of Rutgers University reported a major advance in unraveling these effects. The group made an extremely pure and defect-free crystal of rubrene by vapor deposition. (Rubrene consists of four benzene rings in a chain with four more attached individually as side groups, like two pairs of wings.) They constructed electrodes separately in the form of a "stamp" that was pressed against the rubrene to create a transistor. This technique avoids damage to the rubrene by the electrode-making process. Measurements of the transistor's properties revealed that the flow of charges in organics is slower than in silicon largely because the charges distort the flexible organic crystal lattice and then drag around the distortions with them.

Samuel I. Stupp and his co-workers at Northwestern University have pursued a different technique to reduce the amount of defects and disorder in organic materials. They worked with a short chainlike molecule called phenylene vinylene, attaching a water-repelling molecule to one end of the chain and a water-attracting molecule to the other end. Then they poured a water-based solution of the molecules onto glass, where the molecules self-assembled into well-ordered layers.

Such tightly packed and orderly films have two advantages over more typically disordered polymers: charges flow through the material far more efficiently, and when used as a light source (phenylene vinylene is widely used to make organic light-emitting diodes), the material has fewer luminescence-quenching defects. The group plans to make light-emitting diodes and solar cells out of the material. It won't be long before these various new findings make their way into the designs of commercial devices. —*Graham P. Collins*

New Offensives against HIV

A research insight, a new drug target and an advocacy group assist in fighting the disease

Treatment Action Campaign wants better access to HIV therapies in South Africa.

In the past decade, HIV infection in the industrial world has largely evolved from a virtual death sentence to more of a chronic disease, which is a testament to the efforts of researchers and patient advocates. But the 40 million HIV-positive people worldwide are a somber reminder of the work ahead. Resistant strains of the virus have appeared; citizens in developing countries lack access to lifesaving drugs; and basic questions about the progression of the virus postinfection remain. Yet 2005 brought hopeful news on all fronts.

Researchers know that HIV infection leads to a massive depletion of CD4 white blood cells, but why this happens is still up for debate. Is the virus killing all the cells directly, or is there an indirect mechanism that explains the widespread death? **Daniel C. Douek**, an immunologist in the Vaccine Research Center at the National Institutes of Health, implicates both direct and indirect mechanisms. His work shows that HIV starts in the gut, home to the largest population of the virus's preferred CD4 targets—those with a receptor called CCR5. HIV attacks and kills these cells directly early in the course of the infection.

The mechanism behind CD4 cell death turns indirect as the disease continues. The lack of immunity in the gut allows other pathogens to thrive. This

JAMES F. HULVAT AND SAMUEL I. STUPP *Northwestern University* (*top*); TREATMENT ACTION CAMPAIGN (*bottom*)