



Science + Technology

IN CONGRESS

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House and Senate Think Small: Nanotech Bills Advance

On May 1, the House Science Committee marked up H.R. 766, the Nanotechnology Research and Development Act of 2003, which would authorize \$2.4 billion in federal research funds through fiscal year (FY) 2006 in support of interagency nanotechnology activities. On June 19, the Senate Science, Technology, and Space Subcommittee marked up the 21st Century Nanotechnology Research and Development Act (S. 189). While both chambers strongly endorse the field of nanotechnology, the events highlight differences within Congress over funding for research into ethical and societal impacts.

By far the most interesting engagement during the House mark-up centered around an amendment sponsored by Reps. Brad Sherman (D-CA) and Chris Bell (D-TX) that would have devoted 5 percent of the total federal nanotechnology budget to research into the ethical, legal, and societal impacts (commonly referred to as ELSI). The 5 percent allocation mirrors a similar set-aside for ELSI programs in the interagency Human Genome Project established in 1988.

Opponents to the Sherman/Bell amendment, such as Chairman Sherwood Boehlert (R-NY) and Rep. Brian Baird (D-WA), argued that such a percentage was arbitrary and unnecessary in light of statutory language in H.R. 766 that federal programs include

activities that "ensure that societal and ethical concerns...will be addressed as the technology is developed."

Others, such as Reps. Dana Rohrabacher (R-CA) and Joe Barton (R-TX), raised the specter of establishing a "social elite" of PhDs analyzing societal implications that, according to their view, should be done by the public-at-large. "We don't need a bunch of pontificators," argued Rep. Rohrabacher. He further noted that it is also the role of Congress to debate and determine ethical

issues.

Rep. Baird, who is a PhD psychologist, was quick to come to the defense of social scientists. "I'd like to disassociate myself from my colleague's comments," he stated. "We need bright people" in order to realize the full potential of this burgeoning field. Baird further emphasized that as a member of the House Science Committee "we should not demean the contributions of scientists."

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GOP Moderates Question Stem Cell Policy

As cloning legislation has come to a grinding halt in the Senate, new research results have prompted moderate Republicans in each chamber to focus attention on the issue of federal funding for human embryonic stem cell research.

In March, Johns Hopkins University researchers announced the discovery of a promising new way of growing stem cell lines. Until now, stem cells have been produced with the use of mouse cells as "feeder cells" to keep the stem cells from differentiating into more specialized tissue. However, cells that come into contact with mouse cells can be contaminated with animal viruses, presenting a danger to potential patients. The new technique uses human bone marrow cells instead of mouse cells, eliminating a potential obstacle from scientists' long-term goal of using stem cell transplants to treat conditions such as diabetes and Parkinson's disease.

President Bush's stem cell research policy, announced in a nationally televised address on August 9, 2001, allows federally funded stem cell researchers to work only on cell lines already created at the time of the policy announcement, making research on lines created with the new method ineligible for federal funding.

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"Developing the technology is not enough. A fuel cell vehicle Apollo-like project must also include ... performance targets and timelines."

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Hydrogen: The Gas of the Future?

The Bush Administration has instituted a program—known as the FreedomCar and Fuel Initiative—to replace gasoline-powered automobiles with ones powered by hydrogen fuel cells, an advance that could bring increased efficiency, an end to dependence on foreign oil, cleaner air, and reduced greenhouse gas emissions.

The administration has painted an enticing picture of a hydrogen-based economy that will free the nation from its energy-related problems. This ambitious vision faces numerous obstacles, however, and even its most optimistic proponents

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What follows is a brief outline of the hydrogen technologies under development, their potential benefits, and the hurdles faced in making the hydrogen economy a reality.

Fuel Cells

A hydrogen fuel cell is a device that produces electricity from the reaction between hydrogen and oxygen. The only byproduct of this reaction is water. Fuel cells thus offer a zero emission power source. Fuel cells are also inherently more efficient than the internal combustion engines used in today's cars. Internal combustion engines can convert up to 30 percent of the energy in the gasoline they consume into usable power whereas fuel cells have the potential to operate at up to 55 percent efficiency.

Several types of fuel cells are currently in use. The phosphoric acid fuel cell is the most well-developed and is used in commercial applications such as providing grid

support and back-up power, and powering large vehicles such as buses. Alkaline fuel cells, meanwhile, have been used by NASA to provide electricity on the space shuttle. A third source still under development, polymer electrolyte membrane fuel cells, may have the most promise for transportation applications.

However, fuel cell manufacturers still need to achieve major improvements in cost and durability before their technologies can see widespread use in automobiles. David K. Garman, the assistant secretary of energy for energy efficiency and renewable energy, recently told the Senate Science, Technology, and Space Subcommittee that fuel cells will need to come down in cost by "an order of magnitude." The Department of Energy (DOE) has set a goal of developing a polymer electrolyte membrane fuel cell that will operate at a cost of \$45 per kilowatt by 2010. Current gasoline engines, by comparison, operate at \$35 per kilowatt.

Fuel cell cars will also require the development of supporting technologies, such as electric motors. Other witnesses at the May 7 Senate hearing noted that many of these technologies are currently being developed for hybrid electric vehicles, thus emphasizing the importance of continued investment in hybrids.

Storage

Storage of hydrogen on board a vehicle may be the most significant obstacle to mass production of hydrogen-powered cars, according to Mr. Garman. Hydrogen can be stored as a gas, as a liquid, or in a solid state as part of chemical compounds called metal hydrides. Storage as a gas is the most mature technology, but requires the hydrogen to be compressed to high pressures, since the natural density of hydrogen is very low. Liquid storage, on the other hand, can be achieved at ambient pressures and uses less volume, but requires very low-temperature cryogenic containers and the use of large quantities of energy to convert gaseous hydrogen to a liquid. Metal hydrides may turn out to be the best solution because they do not require extreme pressures or temperatures, but development is much farther down the road.

Delivery

While hydrogen is currently produced

primarily in decentralized locations for use on-site, 17 percent is produced for sale and distribution by about 80 centralized plants. This hydrogen is transported through pipelines and by trucks. Hydrogen pipelines are currently operated in Texas, Louisiana, California, and Indiana.

Hydrogen is not itself an energy source, but is an energy carrier, much like electricity—it is a mechanism for storing energy produced from a wide variety of sources.

Developing a hydrogen infrastructure is one of the major challenges of a conversion to hydrogen-powered cars. Market incentives to build such an infrastructure will not exist until hydrogen-powered cars are on the roads, but hydrogen-powered cars will not be attractive to consumers until a viable infrastructure is in place. DOE's hydrogen initiative aims to address this "chicken-and-egg" problem by ensuring that vehicle and infrastructure technologies are developed simultaneously.

Production

Although hydrogen is the most abundant element in the universe, it is not present on Earth in its pure form. It must be obtained from compounds that contain it, such as fossil fuels and water. Thus, hydrogen is not itself an energy source, but is an energy carrier, much like electricity—it is a mechanism for storing energy produced from a wide variety of sources.

Currently, nine million tons of hydrogen are produced each year mainly for use in chemicals, petroleum refining, metals, and electronics. 95 percent is produced from natural gas by steam reforming. In this process, the natural gas reacts chemically with steam, producing hydrogen and carbon dioxide. Hydrogen can also be produced by electrolysis, where electricity is used to split water into hydrogen and oxygen. Since carbon dioxide is a greenhouse gas, the latter method would be preferable,

but would require increased generation of electricity from either nuclear power plants or renewable sources such as wind and solar power. Technologies are also under development for producing hydrogen from biomass and coal.

The production methods used will ultimately determine whether hydrogen can provide environmental benefits. If it is produced primarily through steam reforming, it will not necessarily provide any reduction in greenhouse gases. However, if it is produced from clean sources such as wind and solar power, it could have a major impact on global warming.

Safety

An additional area of concern for the hoped-for transition to hydrogen is safety.

Reaction in Congress has been enthusiastic. Most of the criticism is that the program is too small, or does not include sufficient parallel efforts in areas such as hybrid technology and renewable energy sources.

Safety risks both real and perceived will need to be addressed as the technology progresses, an issue that came up at a May 20 hearing of the House Energy and Commerce Committee. In response to a question from Rep. Steve Buyer (R-IN), Mr. Garman indicated that safety was not as big an obstacle as some perceive it to be. The main safety concern is flammability, he said, and since hydrogen is very light, it dissipates quickly and may actually be less dangerous than gasoline. He noted that hydrogen gas is not toxic, although a leak can cause suffocation in an enclosed space.

Reaction in Congress to President Bush's hydrogen initiative has been enthusiastic, with most members supporting the vision of a hydrogen economy. Most of the criticism it has faced is that the program is too small, or does not include sufficient parallel efforts in areas such as hybrid technology and renewable energy sources. Sen.

Byron Dorgan (D-ND), for example, says it will require a technology development program on the scale of the Apollo space program that put humans on the moon, and he has proposed a plan to spend \$6.5 billion on the hydrogen effort.

Others, meanwhile, argue that a transition to a hydrogen economy presents a daunting challenge that will require a set of coordinated federal government policies. "Developing the technology is not enough," said Dr. David J. Friedman, an engineer with the Union of Concerned Scientists, at the Senate hearing. "A fuel cell vehicle Apollo-like project must also include clear vehicle production and fuel supply goals, performance targets and timelines along with the resources to make the program successful."



FOR MORE INFORMATION:

DOE hydrogen and fuel cells site:

www.eere.energy.gov/hydrogenandfuelcells

"A 5-Point Plan to Build the Hydrogen Economy." *Wired Magazine*, April 2003

"Vehicle of Change: How Fuel-Cell Cars Could Revolutionize the World," *Scientific American*, October 2002

Union of Concerned Scientists advanced vehicles site: www.ucsusa.org/clean_vehicles/advanced_vehicles/index.cfm

General Motors fuel cell site: www.gm.com/company/gmability/adv_tech/400_fcw/index.html

Shell Hydrogen site: www.shell.com/home/Framework?siteId=hydrogen-en

AAAS NOTES

- FEAR OF "FOREIGNERS" MAY SLOW SCIENTIFIC PROGRESS
www.aaas.org/news/releases/2003/0606xeno.shtml
International students play a critical role on U.S. campuses, and the scientific community has expressed concern that excessive delays in processing non-immigrant visa applications may slow scientific progress. The issue is addressed in this AAAS news article.
- AAAS ATLAS OF POPULATION AND ENVIRONMENT
atlas.aaas.org
Through text, maps, and diagrams, this publication—available free of charge online—analyzes the relationships between human population and the environment.
- GET YOUR DAILY SCIENCE FIX: AAAS SCIENCE UPDATE
www.scienceupdate.com
Listen in RealAudio to compelling minute-and-a-half science news stories.
- SCIENCE AND INTELLECTUAL PROPERTY IN THE PUBLIC INTEREST
sippi.aaas.org
This AAAS project brings a public interest perspective to science and intellectual property issues. The website provides educational materials, links to other resources, and "communities of interest" for specific topics and issues.

Stem Cell Research

Continued from page 1

Initially, the administration compiled a list of 78 eligible cell lines, but to date only eleven of these lines have actually been made available to researchers. Thus, many scientists had been pressing President Bush to revisit the policy even before the Johns Hopkins discovery.

In response to the concerns of stem cell researchers, eleven moderate House Republicans sent a letter to President Bush on May 15 urging him to review his stem cell policy to determine: (1) if enough lines have been made available "for this fast-growing research community;" and (2) "whether

"U.S. scientists continue to express their concern about the quality, longevity, availability and terms of use of the stem cell lines made available under the policy. ... We must have a national policy that allows ... research discoveries to move forward and not handcuff our scientists."

changes should be made to allow for the creation of new sterile, uncontaminated stem cell lines" such as those produced at Johns Hopkins.

"U.S. scientists continue to express their concern about the quality, longevity, availability and terms of use of the stem cell lines made available under the policy," the group wrote. "Specifically, the creation of enough sterile, virus-free lines for potential cell-based therapy is of major concern. ... We must have a national policy that allows such research discoveries to move forward and not handcuff our scientists."

The letter's eleven signatories included Rep. Michael N. Castle (R-DE), a leader of the Tuesday Group, an informal coalition of Republican moderates; Rep. Sherwood Boehlert (R-NY), chairman of the House Science Committee; and Rep. Jim Greenwood (R-PA), who led opposition to the comprehensive cloning ban that passed the House in February and argued instead for a

narrower alternative that would have allowed cloning for research purposes.

In the Senate, meanwhile, Sen. Arlen Specter (R-PA), the chairman of the Labor-HHS Appropriations Subcommittee, held a May 22 hearing on the issue at which he sharply questioned National Institutes of Health (NIH) Director Elias Zerhouni. Dr. Zerhouni defended the Bush Administration's policy and insisted that scientists are moving as fast as possible. There is no current need for new cell lines, he said, although such a need may arise in the future. In fact, Dr. James Battey, the chair of the NIH Stem Cell Task Force, testified that currently the limiting factor in the progress of stem cell research is a lack of scientists trained in the techniques needed to work on stem cells. Sen. Specter criticized Dr. Zerhouni for failing to find a non-government scientist willing to back the administration's position.

Specter also renewed long-standing complaints about communication problems with NIH after Zerhouni informed the subcommittee that 16 of the 78 cell lines eligible for federal funding have not been exposed to mouse cells. Specter contended that Health and Human Services Secretary Tommy Thompson had previously informed him that all of the eligible lines had been exposed to mouse cells, and he sharply rebuked Zerhouni for this "flat-out contradiction." In the past, Thompson has faced criticism from Specter for allegedly allowing his staff to edit communications from NIH scientists to Specter's subcommittee. The 16 uncontaminated lines are not among the eleven cell lines currently available.

Sen. Tom Harkin (D-IA), the subcommittee's ranking member, asked about unpublished reports of 4-5 cell lines that Swedish researchers have derived without the use of mouse feeder cells, and suggested that a change in the administration's policy might be necessary in order to allow NIH-funded researchers to compare these lines to the eleven available lines.

Another witness, Dr. John Kessler of Northwestern University Medical School, confronted Zerhouni's statements head on. He argued that scientists should work on different techniques for developing stem cells "in parallel," but that the administration was forcing scientists to proceed "serially." Both the technique used to derive stem cells and their genetic makeup can alter the cells' properties in important ways, he said, creating a need for the derivation of new lines.

The administration's stem cell policy applies only to federally-funded research, so whether or not President Bush agrees to revisit the issue, privately funded researchers, such as those that produced the recent discoveries as Johns Hopkins, may continue to study new cell lines. As these researchers and scientists abroad report new discoveries, policymakers will face the continuing challenge of ensuring that U.S. policy stays up-to-date. ●●●

FOR MORE INFORMATION:

AAAS Policy Brief: www.aaas.org/spp/cstc/issues/stemcells.htm

NIH Stem Cell Site: <http://stemcells.nih.gov/>

House Considers Change to IP Provision

The House Subcommittee on Courts, the Internet, and Intellectual Property conducted a hearing on June 17 to debate the merits of a legislative vehicle to force states to waive their sovereign immunity rights.

The Intellectual Property Protection Restoration Act of 2003 (H.R. 2344), introduced by Rep. Lamar Smith (R-TX), would require that public institutions waive state sovereignty immunity rights if they wish to take advantage of federal patent and copyright protections. Currently, state sponsored hospitals, research centers, and academic institutions are protected from intellectual property infringement claims. A similar bill (S. 1191) was introduced earlier this month by Sen. Patrick Leahy (D-VT). ●●●

FOR MORE INFORMATION:

www.house.gov/judiciary/courts.htm

CONGRESSIONAL RESEARCH SERVICE

Copies of CRS reports for congressional use are available by calling 202/707-7132.

- **"Sensitive But Unclassified" and Other Federal Security Controls on Scientific and Technical Information: History and Current Controversy (RL31845)**
This report summarizes existing laws that permit governmental restrictions on either privately generated or federally owned scientific and technical information that could harm national security. In addition, it discusses the evolution of federal definitions of "sensitive but unclassified" information, controversies surrounding White House policy directives on such information, and policy options.
- **Science and Technology Policy: Issues for the 108th Congress, 1st Session (RL31846)**
This report provides an overview of key science and technology policy issues pending before Congress, and identifies other CRS reports that treat them in more depth. Topics addressed include homeland security, information technology, energy, nanotechnology and biotechnology.
- **Research and Development in the Department of Homeland Security (RL31914)**
This report describes the R&D programs of the Department of Homeland Security, as well as the impact of program transfers from other federal agencies. It discusses the challenges of internal coordination and management of programs within the new department, as well as the challenges associated with coordinating with external agencies.

GENERAL ACCOUNTING OFFICE

Copies of GAO Publications are available online at www.gao.gov or by calling 202/512-6000.

- **Climate Change: Information on Three Air Pollutants' Climate Effects and Emissions Trends (GAO-03-25)**
This report examines the extent of agreement among scientists regarding the effect on the climate of three air pollutants—black carbon (soot), ground-level ozone, and sulfate aerosols. In addition, it analyzes seven countries' efforts to control these pollutants, trends in these substances in these countries over the past 2 decades, and estimates for the next decade. The report also provides a summary of the relationship between economic growth and environmental pollution.
- **SARS Outbreak: Improvements to Public Health Capacity Are Needed for Responding to Bioterrorism and Emerging Infectious Diseases (GAO-03-769T)**
This report examines the preparedness of state and local public health agencies and hospitals for responding to a large-scale infectious disease outbreak and the relationship of federal and state planning for an influenza pandemic to preparedness for emerging infectious diseases. It found that most hospitals lack

the capacity to respond to large-scale infectious disease outbreaks.

THE NATIONAL ACADEMIES

Government offices may obtain single complimentary copies by calling the Office of Congressional and Government Affairs at 202/334-1513. Others may order copies from the National Academy Press (800/624-6242, www.nap.edu).

- **Ensuring the Quality of Data Disseminated by the Federal Government (ISBN: 0-309-08857-7)**
This report of the National Research Council summarizes March and May 2002 workshops where federal officials, researchers, and others discussed how individual federal agencies could develop their own guidelines for protecting data quality, to comply with overarching rules established by the White House Office of Management and Budget. The goal of the workshops was not to draw conclusions, but to consider various viewpoints from individuals in the scientific and legal communities.
- **The Measure of STAR: Review of the U.S. Environmental Protection Agency's Science to Achieve Results (STAR) Research Grants Program (ISBN: 0-309-08938-7)**
This report analyzes the performance of EPA's competitive research grants program, Science To Achieve Results (STAR). It concluded that the program has yielded significant new findings and knowledge critical for EPA's decision-making process. Furthermore, the report recommends that STAR should remain an important part of the agency's overall research program, however, it warns that the program does not have sufficient funds to support all of the top-rated research proposals it receives.
- **Protecting Participants and Facilitating Social and Behavioral Sciences Research (ISBN: 0-309-08852-6)**
This report examines how Institutional Review Boards (IRBs)—groups that review the ethics of proposed studies involving human subjects—can improve practices related to data confidentiality and informed consent in social and behavioral sciences research, which typically involves methods such as surveys and field observation.
- **Hidden Costs, Value Lost: Uninsurance in America (ISBN: 0-309-08931-X)**
This report finds that the United States loses at least \$65 billion to \$130 billion every year because of the poorer health and earlier death experienced by the 41 million Americans who lack health insurance, a hidden cost of uninsurance that could be recouped by extending health coverage to all. The report, which is part of a series examining the consequences of being uninsured for individuals, families and communities, provides an economic analysis of the costs of uninsurance for society overall.

scientific definitions

1. The act of making clear and distinct.
2. the act of stating a precise meaning or significance.

HYDROGEN FUEL CELL TERMS

FUEL CELL A device that uses hydrogen and oxygen to create electricity through an electrochemical process.

FUEL CELL STACK Individual fuel cells connected in series. Fuel cells are stacked to increase electrical current.

CATALYST A chemical substance that increases the rate of a reaction or allows it to proceed at a lower temperature. In a fuel cell, the catalyst facilitates the reaction of oxygen and hydrogen. It is usually made of platinum powder very thinly coated onto carbon paper or cloth.

ELECTROLYTE A substance that separates into positively charged and negatively charged ions in the presence of water, a solvent, usually making the water solution capable of conducting electricity.

ALKALINE FUEL CELL (AFC) A type of hydrogen/oxygen fuel cell in which the electrolyte is concentrated potassium hydroxide (KOH), and hydroxide ions (OH⁻) are transported from the cathode to the anode. Temperature of operation can vary from <120°C to approximately 250°C depending upon electrolyte concentration.

PHOSPHORIC ACID FUEL CELL (PAFC) A type of fuel cell in which the electrolyte consists of concentrated phosphoric acid (H₃PO₄) and protons (H⁺) are transported from the anode to the cathode. The operating temperature range is generally 160-220°C.

POLYMER ELECTROLYTE MEMBRANE FUEL CELL (PEMFC or PEFC) A type of acid-based fuel cell in which the transport of protons (H⁺) from the anode to the cathode is through a solid, aqueous membrane impregnated with an appropriate acid. The electrolyte is called a polymer electrolyte membrane (PEM), which is similar in consistency to thick plastic wrap. The fuel cells typically run at low temperatures (<100°C). Also known as proton exchange membrane fuel cells.

HYDROGEN (H₂) The simplest and lightest element in the universe, which exists as a gas except at low cryogenic temperatures. Hydrogen gas is colorless, odorless and highly flammable when mixed with oxygen over a wide range of concentrations. Hydrogen forms water when combusted, or when otherwise joined with oxygen, as within a fuel cell.

LIQUEFIED HYDROGEN (LH₂) Hydrogen in liquid form. Hydrogen can exist in a liquid state, but only at extremely cold temperatures. Liquid hydrogen typically has to be stored at -253°C (-423°F). Cooling and compressing hydrogen into its liquid state requires energy, resulting in a net loss of about 30 percent of the energy that the liquid hydrogen is storing. Storage tanks are insulated to preserve temperature and reinforced to store the liquid hydrogen under pressure.

>>> *More definitions on next page*

Nanotech Bills

Continued from page 1

Ultimately, the Sherman/Bell amendment failed to pass, but this did not stop the debate on ethical issues from creeping back onto the House floor. During intense discussions over an amendment introduced by Rep. Bell to require the inclusion of toxicological and environmental impact studies, Rep. Brad Miller (D-NC) opined, "I want to make sure we are not turning loose upon the world a molecular, atomic kudzu." The Bell amendment was rejected by a vote of 214-209, but the bill as a whole passed the House by a wide margin, on a vote of 405-19.

Nanotechnology research involves manipulating matter at the atomic and molecular level. One nanometer is a billionth of a meter. Researchers foresee promising applications in a diverse array of science and engineering fields, including electronics, medicine, and environmental technology. Proponents of nanotechnology envision improved water filtration devices for cleaning the environment, and nano-sized robots injected into the body that can deliver drugs to targeted cells.

Others, however, express concern that unleashing these promising products prematurely could unintentionally lead to new health and environmental hazards that science and society will be ill-prepared to handle.

While the House bill places the responsibility of defining and managing ELSI issues among the participating agencies to be coordinated through an Interagency Committee, the Senate bill would elevate the ethical and societal components of the federal program.

The 21st Century Nanotechnology Research and Development Act, introduced by Senators Ron Wyden (D-OR) and George Allen (R-VA), would create a separate American Nanotechnology Preparedness Center funded through the National Science Foundation at \$5 million annually. Such a center would conduct studies to help decision-makers better anticipate ELSI issues likely to arise as the field matures.

The center was heartily endorsed by Dr. Davis Baird, a professor of philosophy at the University of South Carolina, who stated at a May 1 Senate hearing that it was "important for a centralized voice to be heard above the roar of science" when consider-

ing the ethical and social implications of nanotechnology.

The House bill authorizes three-year funding for NSF, the Department of Energy, National Aeronautics and Space Administration, National Institutes of Standards and Technology, and Environmental Protection Agency between FY 2004-2006. The Senate bill would also extend authorization to the National Institutes of Health, Department of Justice, Department of Transportation, and Department of Agriculture. When initially introduced, the Senate bill provided funding for a single year at \$677 million. During the June mark up, they passed an amended version that would authorize a \$4.7 billion program over a five-year period beginning in FY 2004.

Another key difference between the House and Senate legislative visions is the management and composition of an external advisory committee to provide oversight and assessment of the progress of the interagency research programs. The House bill would give responsibility to the existing President's Council of Advisers on Science and Technology (PCAST), who would tap nanotechnology and ethical experts as appropriate. The Wyden bill, on the other hand, would create a separate stand-alone National Nanotechnology Advisory Panel that would include such experts as part of its membership.

PCAST has already taken steps to establish its role as an oversight committee. At a June 10 meeting, it discussed a Nanotechnology Work Plan. The plan includes the creation of three task forces comprised of PCAST members, each to explore a special topic: Materials/Electronics/Photonics, Energy/Environment, and Medical/Bio/Social.

There was no word as to when the Senate bill will go to the floor or a conference committee is likely to convene, but aides in

both the House and Senate acknowledge that they must reconcile numerous differences before any bill can be signed into law.

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FOR MORE INFORMATION:

Nat'l Nanotech. Initiative: www.nano.gov

NSF nano page: www.nsf.gov/home/crssprgm/nano/start.htm

Foresight Institute: www.foresight.org

Bill Joy, "Why the Future Doesn't Need Us," Wired Magazine, www.wired.com/wired/archive/8.04/joy_pr.html

Scientific Definitions *Continued from previous page*

OXYGEN (O₂) A colorless, tasteless, odorless, gas that makes up about 21 percent of air. Oxygen is capable of combining rapidly with all elements (except inert gases) in the oxidation process called burning (combustion). Oxygen combines very slowly with many metals in the oxidation process called rusting.

CARBON DIOXIDE (CO₂) Carbon dioxide is a colorless, odorless, noncombustible gas. It is present in the atmosphere as a result of the decay of organic material and the respiration of living organisms, and it represents about 0.033 percent of air. Carbon dioxide is produced by the burning of wood, coal, coke, oil, natural gas, or other fuels containing carbon, by the action of an acid on a carbonate, or naturally from springs and wells. Carbon dioxide is a greenhouse gas and is a major contributor to the greenhouse effect.

HYDROCARBON (HC) An organic compound containing only carbon and hydrogen, usually derived from fossil fuels such as petroleum, natural gas, and coal: an agent in the formation of photochemical smog.

ELECTROLYSIS The process where an electric current is passed through an electrolytic solution or other appropriate medium, causing a chemical reaction (e.g., the transformation of water (H₂O) into H₂ and O₂).

REFORMING A chemical process that reacts hydrogen-containing fuels in the presence of steam, oxygen, or both into a hydrogen-rich gas stream.

NATURAL GAS A naturally occurring gaseous mixture of simple hydrocarbon components (primarily methane) used as a fuel.

RENEWABLE ENERGY A form of energy which is never exhausted because it is renewed by nature (within short time scales; e.g. wind, solar radiation, hydro power).

SOURCE: DOE Office of Energy Efficiency and Renewable Energy, www.eere.energy.gov/hydrogenandfuelcells/glossary.html

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Frontiers in Science



When Your Rubber Hand Hurts • Neuroscientists at the University of California, San Diego, have found that people react to acts committed on fake rubber hands as though they were parts of their own bodies. The experimenters sat volunteers at a table, hid their right hands from view and placed fake rubber hands in view. When the real and fake hands were tapped and stroked simultaneously, the subjects reported feeling as if the sensations were coming from the rubber hand. The researchers then bent one of the subjects' real fingers back slightly while bending one of the rubber fingers back to what would be a painful position, causing the subjects to think that their real fingers were bent back farther than they actually were. The subjects also exhibited stress responses, and some even reported feeling pain. Amazingly, subjects showed a similar response to "painful" acts committed on the table. When Band-Aids were placed on both the real hand and the table, and only the Band-Aid on the table was ripped off, many of the subjects winced.

---> *Proceedings of the Royal Society, June 6, 2003*

Electric Clothing • In an advance toward a possible application of nanoscale science, researchers at the University of Texas, Dallas, have created fibers from molecules known as carbon nanotubes. Stronger than steel, tougher than Kevlar, and hundreds of yards long, the fibers also conduct electricity, suggesting the possibility of weaving them into ultra-strong, bullet-proof military garb that could be used to power sensors, electronics, and communications gear in the fabric. Carbon nanotubes are tiny cylindrical molecules made from carbon atoms, which were discovered in 1991. Scientists and engineers have touted the numerous potential applications that could arise from their light weight, extraordinary strength and conductivity.

---> *Nature, June 12, 2003*

Gecko Tape • Inspired by the amazing climbing ability of the gecko, scientists at the University of Manchester in England have developed a reusable tape strong enough to hold the weight of a person by an area the size of a human palm. Geckos use the millions of tiny hairs on the bottoms of their feet to climb, and recent research has revealed the physical mechanism that makes these hairs so sticky: intermolecular van der Waals forces hold the hairs to solid surfaces, and millions together can hold a gecko's weight. The Manchester researchers imitated this phenomenon by forming tape with dense arrays of microscopic plastic pillars that are flexible enough to adhere to uneven surfaces.

---> *Nature Materials, June 1, 2003*