The American Chemical Society's Award-Winning Publication

Chemistry

WINTER 2006

The Ice That *Burns*

Gas hydrates promise as an abundant new source of energy is sparking global R&D efforts *page 27*

And Don't Miss...

A conference nobel and unforgettable, patent or perish, schizotypals we've known, sustainability and green chemistry, personal finance pointers for 2006, a weighty question about 6.022 x 10^{23}/0.012 unbound carbon 12 atoms, and more, inside.

PUBLISHED BY THE AMERICAN CHEMICAL SOCIETY

chemistry.org/Chemistry

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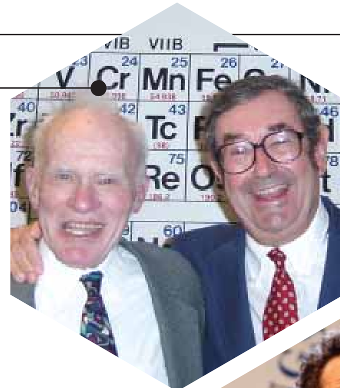
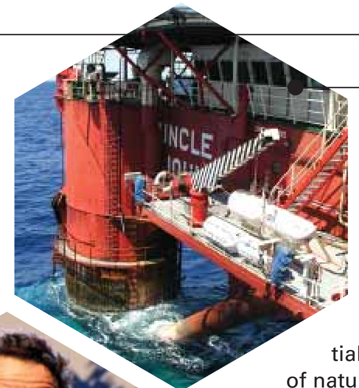
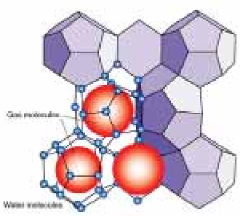




WHAT'S IN THE LOGO?

Gas Hydrates: Ice That Burns

Hydrates are crystalline solids similar to ice, built from a gas molecule—often methane—surrounded by a cage of water molecules. Many gases can form hydrates, including carbon dioxide, hydrogen sulfide, and low-carbon-number hydrocarbons. Methane forms most marine hydrates, which occur in enormous quantities and hold promise for providing a new source of energy. See *Burning Questions about Gas Hydrates,* Page 27.



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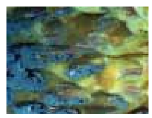

MARK MASLIN, UNIVERSITY COLLEGE LONDON

Burning Questions about Gas Hydrates
Pink "iceworms" graze on chemosynthetic bacteria inhabiting exposed hydrate deposits in the Gulf of Mexico.

DEPARTMENTS

Chemistry

Chemistry, published three times a year for American Chemical Society members, focuses on the science and people in chemistry.

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Chemistry is a newspaper published for ACS members interested in learning more about the chemical sciences and ACS.

Readers' comments are welcomed and should be addressed to Michael Woods, *Chemistry* editor, Othmer–1210, ACS, 1155 16th St., NW, Washington, DC 20036, or e-mailed to chemistry@acs.org.

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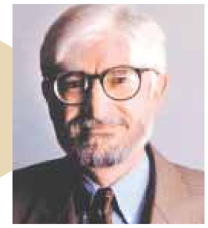
EDITORIAL



Paper or pixels? What's your pleasure? Almost everyone has an opinion about the upside and downside of reading journals, magazines, newspapers, and other publications on paper or online. Most of us get some information from both sources, and would be mighty uneasy about *having* to switch to 100% online content.

I faced that prospect in 2003, at the start of a two-year adventure telecommuting from my regular job as a newspaper science writer, and from this wonderful opportunity to edit *Chemistry.* It was a long-distance telecommute—from Europe. Keep reading *Chemistry,* and a few of the details may get into print sometime in the future.

Access to ACS and other journals is just as essential for individuals who write about science as for those who do science. I read more than a dozen journals regularly, in addition to five daily newspapers and an assortment of magazines. The move to Europe raised the horrible prospect of getting behind the curve of scientific discovery while waiting for friends to forward journals and losing touch with day-to-day news.

The only alternative was to switch—just about 100%—from paper to pixels. Those are "picture elements," the small grid-like units that make up an image on a computer monitor. I never touched a paper copy of *Chemical & Engineering News,* for instance, in those two years. Nevertheless, a computer and a fast Internet connection enabled me to read every edition. Ditto for every other journal, newspaper, and magazine on my regular reading list.

The switch to pixels was surprisingly seamless and pleasurable. A quick scroll through the table of contents identified interesting content. Sometimes I'd read articles right from the monitor. Other articles got downloaded into my PocketPC for reading on the bus or Metro. Some got saved on the computer hard disk for later reading. I also printed articles, using that Portable Document Format (PDF) that retains the actual look and layout of each page in a publication.

When I count the benefits of those two years abroad, and the ways that experience nudged me toward thinking and working in new ways, the forced shift away from paper and into pixels emerges as one of the most important.

Even though I'm back in Washington, DC, with easy access to paper publications again, online reading continues to make life easier by providing quick and efficient access to information. To me, a computer monitor beats fumbling with the pages of a newspaper any day.

This edition of *Chemistry* is the perfect time to raise the paper-or-pixels question. It is the first of at least a year's worth of *Chemistry* that will be published exclusively online.

We'll give readers an e-mail notification when each edition is posted to the ACS website (chemistry.org). The website also will carry a notice and a link for the thousands of members who visit it often and connect with its rich assortment of information about the science and profession of chemistry. We'll follow about the same publication schedule, so look for new editions of *Chemistry* in April and September.

Chemistry online will retain the familiar content of the paper edition. We'll keep providing the feature articles, columns, and ACS membership news that got such strong reader approval in our 2005 readership survey.

Enough said. Scroll on into this edition. And as you flip the virtual pages of *Chemistry* online, please let us know (chemistry@chemistry.org) your thoughts about the paper-or-pixels question, and share your suggestions for the future. ⬢

Michael Woods

Michael Woods (ACS '96), editor of Chemistry, *is a science journalist and author in Washington, DC. His most treasured writing award is the ACS Grady-Stack Award for Interpreting Chemistry to the Public, named for News Service pioneers James T. Grady and James H. Stack.*

Patents Here and There

"Patent or perish" may eventually rival "publish or perish" as an axiom for success in science, making knowledge of global patent policy essential.

"Publish or perish" has always been a fact of scientific life. Without publications, your work, no matter how earth-shattering, is diminished in the eyes of those who might hire you, keep you employed, and advance your career. If that's not pressure enough, there's a corollary that you're also going to learn to live by as you grow in your professional life: "Patent or be penniless."

Depending on where in the world you work, the pressure to publish and the pressure to patent might not always be in sync with one another.

In today's hyper-competitive world, where research dollars are tight and the line between academia and industry becomes blurrier each day, patents are becoming as important as publications on your *curriculum vitae.* Patents now count toward tenure and promotion at most universities, and since 1980, the U.S. government has actually required universities to patent any federally funded discoveries that might have commercial value. And—Be honest!—who among you wouldn't want to see your discoveries turn into royalties some day?

When I was a graduate student in the biochemistry department at the University of Wisconsin in Madison, my fellow students and I were well aware of the importance of patents because of the legacy of that department. Patents relating to vitamin D and the anticoagulant Warfarin had generated millions of dollars for the department and the university.

A Convoluted World of Patents

That knowledge evidently had no impact on me. As a second year student, I invented a piece of equipment for drying NMR solvents and injecting the dried solvent into a sealed NMR tube. Although I published the work, I didn't think to patent it. Too bad for me—less than a year after my paper was published, I was touring a chemistry lab in France when I noticed a spiffy commercial device that looked exactly like the one I'd invented. It turns out that a small company in England had seen my paper and decided to build and sell the device—several thousand of them in fact. The person I talked to actually thanked me for not patenting my work. There went my opportunity for endless wealth and fame.

But why, you ask, am I writing about patents when I'm supposed to be telling you about international matters?

The reason is that the world of patents is a convoluted one, and the procedures you must follow to secure a valid patent in the United States differ from those of the rest of the world. To help you avoid the same fate I suffered—no, not becoming a writer because I failed to patent my invention—here's some advice to keep in mind when you discover the cure for cancer and our world's energy woes.

To obtain a patent, your invention must be novel and not obvious to a person familiar with your research field. By novel, the world's patent offices mean that the invention hasn't been revealed to the public, whether it be in a publication or at a seminar at an open meeting. It is the interpretation of the novelty provision that can cause U.S. scientists heartburn when it comes to protecting their inventions in Europe and Japan.

U.S. patent law allows you one year to file a patent from the day you first disclose your invention. If you give a departmental seminar on your work, present a poster at an ACS meeting, or file your doctoral dissertation with your university library, you must file your U.S. patent application within 365 days.

But here's the rub: The moment you hand that dissertation to the reference librarian or tack your poster up in the exhibit hall, your work is no longer novel, according to European and Japanese law. In other words, to protect your invention in Europe and Japan, you must file your patent application before revealing your work to the public.

First To Invent Versus First To File

Another important difference between the United States and the rest of the world is that the U.S. patent system operates on a "first to invent" basis, while the rest of the world operates on a "first to file" basis. So even if you do file a European patent before you disclose your invention, you might still lose your patent rights if someone else files their application before you file yours, even if you document that you made your discovery first.

The Lesson?

Don't procrastinate when it comes to patents. If you want to protect your intellectual property, whether you're working in the United States or overseas, the first person to tell about your discovery is your boss or adviser, and the second person should be your institution's intellectual property officer.

I missed my opportunity; don't miss yours. ⬢

Joe Alper (ACS '97) lived the life he writes about as Chemistry's *Global Perspectives columnist. He held chemistry jobs in London and Paris before returning to the United States and a career as a noted freelance science and medical writer in Louisville, CO.*

FROM THE DESK OF THE

Executive Director

It's a pleasure to launch this first issue of *Chemistry* in 2006 with my warmest greetings for a happy, healthy, and prosperous New Year! This year, the American Chemical Society celebrates its 130th anniversary, and it promises to be a transformative year for our members and the chemical and allied sciences.

Why do I say this? Because so many projects begun in the past two years are coming to fruition and will provide additional value to our more than 158,000 members. You told us in the recent member satisfaction survey what you value most, and ACS governance and staff are trying to deliver for you. Each of us has a stake in the success of these projects, and I'd like to share an update on several important areas.

In December, the ACS Board of Directors approved funding for several new programs. Among them is one brought forward by the Society Committee on Education—a pilot program for high school chemistry clubs to get more high school students involved in chemistry. Mary Kirchhoff (ACS '86), who is serving as Acting Director of the Education Division following the retirement of long-time director Sylvia Ware (ACS '80), is overseeing this program.

Another new program is "New Leaders for New Times," a leadership development plan, spearheaded by the ACS Board of Directors, which expands and coordinates ACS activities focused on recruiting, retaining, and training ACS volunteer leaders. The thousands of ACS volunteers who donate their time in committees, Council, local sections, divisions, and for National Chemistry Week have made ACS the envy of all scientific societies. As 2006 ACS President Ann Nalley (ACS '71) says, the Society simply couldn't exist without our volunteers. The Membership Division, under the direction of Denise Creech (ACS '90), provides support for this program.

The ACS Board of Directors also increased funding in 2006 for the ACS Green Chemistry Institute, which has been serving as a catalyst for the adoption of green chemistry and engineering principles throughout the world. In recognition of the institute's stature and accomplishments, the ACS Green Chemistry Institute and its director, Paul T. Anastas (ACS '95), were named to the 2005 *Scientific American* 50—the magazine's annual list recognizing outstanding leadership in science and technology. While the magazine officially recognizes GCI and Anastas, Anastas feels strongly that the honor belongs to all who work in the fields of green chemistry and engineering. Indeed, the Nobel Prize in Chemistry in 2005 went to three chemists—among them Caltech's Robert Grubbs (ACS '64) and MIT's Richard Schrock (ACS '75) (both long-time ACS members and ACS Award winners)—whose work in olefin metathesis was cited as contributing to green chemistry.

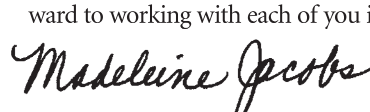
The ACS Board approved funding for the multiyear Web presence initiative to reinvent our multiple Web presences, a project under the direction of *C&EN* Editor-in-Chief Rudy Baum (ACS '95). Later this year, members will begin to see the first changes in chemistry.org as a result of this initiative. We are pleased to welcome Paul LaPorte as our new Web Strategy Director and John Sullivan as our new Chief Information Officer, Washington IT, both of whom are working closely with Baum and the entire ACS staff to make the ACS Web presence the best in the world.

This month, the ACS Publications Division, led by Robert Bovenschulte (ACS '97), launched *ACS Chemical Biology,* a journal serving the exciting interface of chemistry and biology. ACS was fortunate to secure the talents of Laura L. Kiessling (ACS '82) as its editor-in-chief. Kiessling is a professor at the University of Wisconsin and a MacArthur Foundation Fellow. *ACS Chemical Biology* provides rapid communication of peer-reviewed research reviews, concept articles, perspectives, news features, and highlights from other ACS journals. Its website will be the authoritative gateway for the field of chemical biology. Visit www.acschemicalbiology.org. Also new from the Publications Division is a revamped *C&EN* Online with a new look and RSS (Really Simple Syndication) feeds, which permit a reader to rapidly review a large number of sites.

CAS, led by Robert Massie (ACS '00), continues its history of exciting innovations to transform the research experience for chemical scientists. Among the innovations announced or launched in 2005 and this year are SciFinder with similarity searching, Mac OS X for SciFinder and SciFinder Scholar, STN AnaVist, and CAS Mobile. Each of these digital search tools enhances the speed and ability of the individual scientist, as well as teams of researchers, in the discovery process. For more information about CAS products and services, visit www.cas.org.

Finally, in 2005, thousands of members participated in developing a new Vision statement for ACS. It seems only appropriate to unveil this Vision statement during a major anniversary year. As I write this column, the ACS Board of Directors is putting the final touches on the statement, and it will be rolled out to the full membership soon. I hope it will inspire you as much as it inspires me!

I have only touched upon a few of the most visible projects. I mentioned others in my autumn 2005 column in *Chemistry.* What else should we be doing? Write to me at executivedirector@acs.org. I am looking forward to working with each of you in 2006!



Madeleine Jacobs (ACS '96)
Executive Director & CEO

Battle of the Algorithms

Computers can chalk up another victory over the human brain. After beating people in all kinds of mental tasks, from number crunching to playing chess, they now can create programs that solve complex problems better than software written by human beings.

Uli Grasemann and Risto Miikkulainen, of the University of Texas at Austin, have reported that a computer-generated "algorithm" can digitally improve images of fingerprints better than the FBI's human-designed program currently can.

The FBI started using that program in the 1990s to digitize what was then a database of 200 million fingerprints. They were stored in the form of inked impressions on paper cards. Digitizing each one, at the resolution of 500 dots per inch needed to assure clarity, requires 10 megabytes (MB) of computer memory per fingerprint card. A CD-ROM holds about 650 MB.

With 30,000 new cards floating in *every day,* the FBI needed an algorithm to save storage space.

Algorithms are computer programs that systematically solve a problem. Image compression algorithms try to minimize the number of bytes in graphics files while preserving as much image quality as possible. Fewer bytes mean less storage space and faster file transfer times.

Grasemann and Miikkulainen applied "genetic" algorithms to solve the fingerprint compression puzzle. These programs evaluate and improve a population of possible solutions to a problem in a stepwise fashion. The new program then evolves by letting good solutions produce offspring and bad solutions die out—almost like inheritance and mutation in biology. Hence, the name "genetic" algorithm.

The researchers provided a computer with basic programming instructions for compressing graphic images and waited for a better algorithm to evolve. After 50 generations, the genetic algorithm consistently outperformed the one humans created.

"It is fascinating and a little ironic that computers can come up with new and creative solutions that human experts miss," Grasemann said. "There is definitely tremendous potential to increase the quality of work in many areas of science and engineering using genetic algorithms." ⬢

What a Typical Schizotypal!

Ever search for just the right word to describe a colleague who is… well…an oddball, flake, nonconformist, geek, eccentric, anomaly? Please be more scientific, and describe that crank as a "schizotypal personality." And look at the positive side if you hear others whispering "schizotypal" about you.

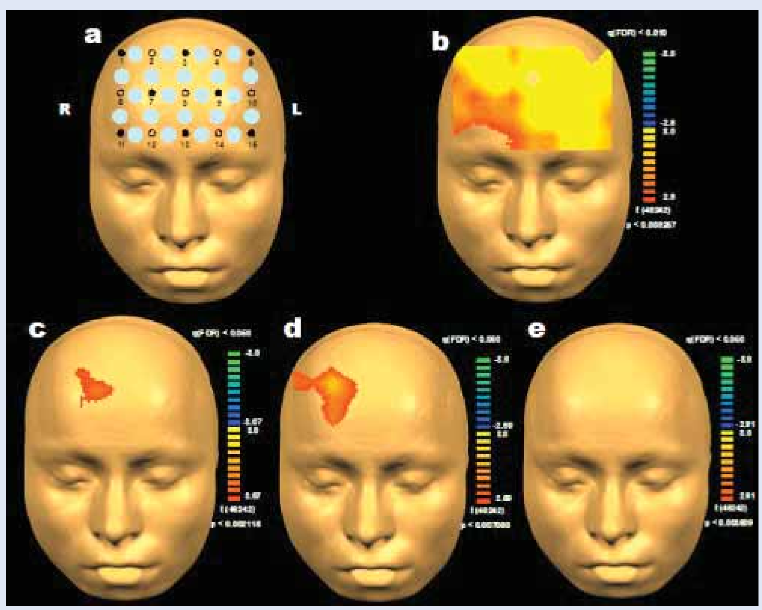
Vanderbilt University psychologists Brad Folley and Sohee Park have reported that odd behavior—with a quirky or socially awkward approach to life—may be the key to becoming a great scientist, inventor, artist, or composer. It is believed to be the first neurological evidence that people with a schizotypal personality are more creative than other individuals and rely more heavily on the right sides of their brains to access their creativity.

Psychologists have speculated that some of the greatest creative luminaries had schizotypal personalities. Among them: Vincent Van Gogh, Albert Einstein, Emily Dickinson, and Isaac Newton.

"The idea that schizotypes have enhanced creativity has been out there for a long time, but no one has investigated the behavioral manifestations and their neural correlates experimentally," Folley said. "Our paper is unique because we investigated the creative process experimentally and we also looked at the blood flow in the brain while research subjects were undergoing creative tasks."

In the scientific community, the popular idea that creativity exists in the right side of the brain is regarded as ridiculous, Folley said, because people need both hemispheres to make novel associations and to perform other creative tasks.

Brain scans, however, showed that schizotypes had "hugely increased" activity of the right hemisphere, Folley pointed out. ⬢



COURTESY OF PARK LABS

NEAR INFRARED SPECTROSCOPY SCANS show schizotypes, schizophrenics, and normal controls during divergent thinking tasks. Image (a) shows probe placement for the brain scan. Image (b) shows the increase in oxyhemoglobin, which corresponds to an increase in brain activity, that occurred in the right and left hemispheres of all three groups. Image (c) shows the increase in oxyhemoglobin in the right hemisphere of schizotypes compared to normal controls. Image (d) shows much greater activation in schizotypes than in schizophrenics. Image (e) compares the different reactions of schizophrenics and normal controls, showing no difference between the two groups.

Power Walking

Check out a typical business traveler, and you'll likely find electronic devices galore stuffed into pockets, purses, and briefcases. Powering those cell phones, Blackberries, PocketPCs, personal digital assistants (PDAs), and digital audio players is no problem when electrical outlets are available.

It's a huge problem, however, for scientists doing field work, hikers on long treks, soldiers, and relief workers in disaster areas. Replacement batteries can account for up to 25% of the weight of the packs that such individuals carry.

Muscle physiologist Lawrence Rome and colleagues at the University of Pennsylvania may have the solution. It is a backpack that generates electricity as a person walks, which Rome describes as "a breakthrough in development of a portable and renewable human-driven energy source."

The most notable previous innovations in the field were gadgets that fit into the heel of a shoe and produce small amounts of electricity—about 20 milliwatts. Rome's electric backpack, which generates up to 7.4 watts, represents a 300-fold improvement.

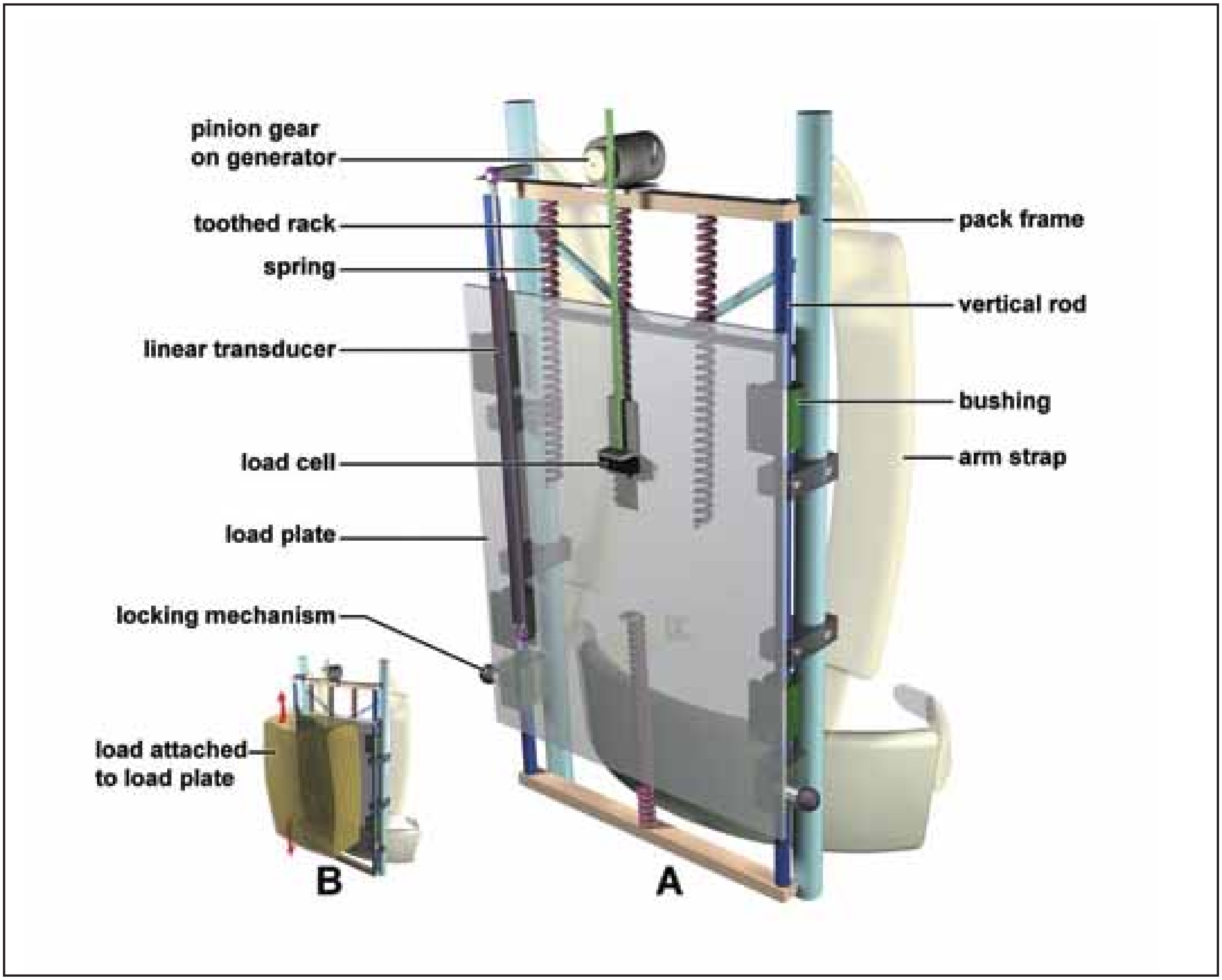
He used a muscle physiologist's knowledge of the mechanics of walking to develop the device. Walking at a brisk pace, for instance, makes each hip rise and fall 4–7 centimeters, expending a lot of energy.

The suspended-load backpack taps into that vertical movement by using springs to suspend the load from the pack's fixed frame. The load rises and falls during walking, running a toothed rack over a gear that is attached to a small generator on the frame.

There you go. The mechanical energy of walking converts into electrical energy.

A 38-kilogram pack can generate about 7 watts when the wearer hikes at a brisk pace, and a more manageable 29-kilo pack makes 4 watts at a leisurely 5.5 kilometers per hour.

"This electricity generation can help give field scientists, explorers, and disaster-relief workers freedom from the heavy weight of replacement batteries and thereby extend their ability to operate in the field," Rome said. ⬢



ELECTRIFYING BACKPACK

RUBLES

Raising the Rubles

The Russian Ministry of Science and Education has announced that most scientists in the country will get a huge pay raise—quintuple the current average salary. Don't turn green with envy quite yet. Science hasn't fared well since the fall of the former Soviet Union in 1991, and Russian researchers have had to scramble to survive. The raise will boost the average weekly paycheck to the equivalent of about $260. ⬢

Chemical Dynamics from Outer Space

An "astonishing" hidden unity exists between the motion of objects in outer space and transition states in chemical reactions, according to a report in the October 2005 *Notices of the American Mathematical Society* (free online at www.ams.org). Entitled "Ground Control to Niels Bohr," it describes an almost perfect parallel between the mathematics describing celestial mechanics and the math governing the energy levels of electrons as reactants turn into products. ⬢

When Salt Meets the Road

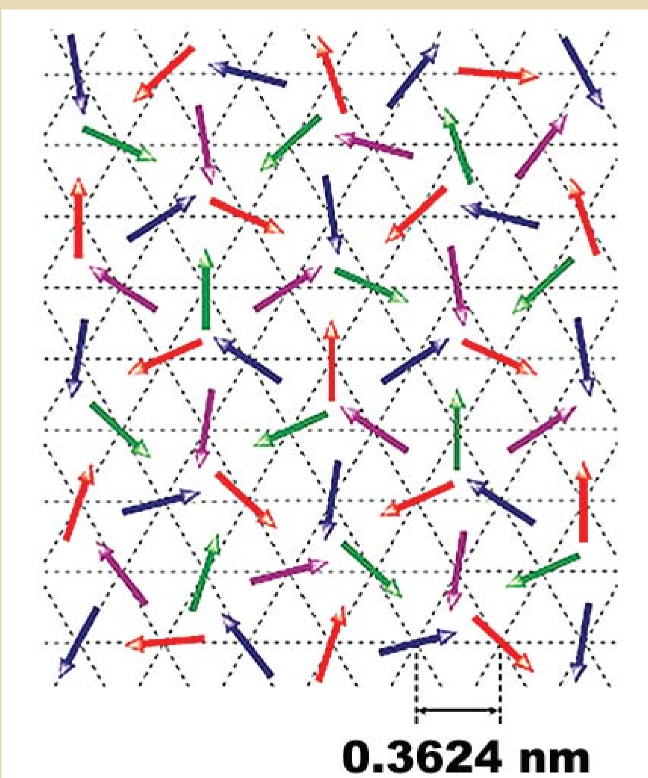
With snow blowing through a leaden January sky, your hands tighten on the steering wheel as you ease down the ramp onto the expressway. Thank goodness! The salt trucks have been through.

The use of salt—15 million tons annually in the United States—to de-ice roads prevents accidents and saves lives. Since the use of salt for highway de-icing became widespread in the 1960s, concern also has grown about its environmental effects. Scientists have known relatively little, however, about how much the chloride in de-icing salts increases the salinity of rivers and lakes.

Sujay Kaushal and colleagues at the University of Maryland studied wintertime chloride concentrations in bodies of water near heavily salted roads in New York, New Hampshire, and Maryland. Chloride concentrations of about 250 milligrams per liter (mg/L) make water harmful to plants and animals, they said. The researchers found chloride concentrations about 20 times higher—nearly 5,000 mg/L.

In addition to harming vegetation and affecting the drinkability of water, the researchers said, such levels could impair bacterial processes that help remove pollutants from waterways. ⬢

Liquid Magnetic State?



S. NAKATSUJI (ACS '99) ET AL., *SCIENCE*

MULTICOLORED ARROWS show the disordered array of magnetic spins associated with the electrons of nickel within $NiGa_2S_4$.

Scientists at Kyoto University in Japan have synthesized a material that may demonstrate the existence of a highly unusual "liquid" magnetic state that theoreticians first proposed more than 30 years ago. The material is nickel gallium sulfide ($NiGa_2S_4$).

Researchers from the Johns Hopkins University and the University of Maryland joined their Japanese colleagues to study the polycrystalline sample of $NiGa_2S_4$ by means of neutrons and X-rays at the National Institute of Standards and Technology Center for Neutron Research in Gaithersburg, MD.

The team found that the triangular arrangement of the material's atoms appears to prevent alignment of magnetic "spins"—the characteristic of electrons that produces magnetism.

A "liquid" magnetic state occurs when magnetic spins fluctuate in a disorderly, fluid-like arrangement that does not produce an overall magnetic force. A liquid magnetic state may be related to the similarly fluid way that electrons flow without resistance in superconducting materials.

"The current work shows that at an instant in time the material looks like a magnetic liquid," said Johns Hopkins' Collin Broholm. "But whether there are fluctuations in time, as in a liquid, remains to be seen."

Broholm and colleagues did their neutron experiments with an instrument called a disk chopper spectrometer. The only one of its kind in North America, it sends bursts of neutrons of the same wavelength through a sample. More than 900 detectors arranged in a large semicircle determine exactly where and when the neutrons emerge, providing information key to mapping electron spins. ⬢

CHEM.WWW BY KILI LAY

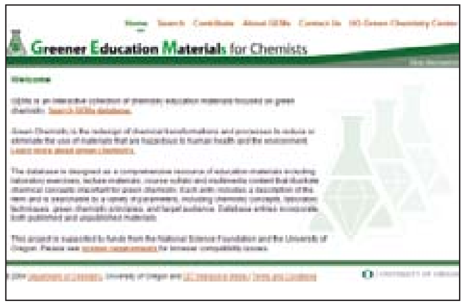
Fast Flying Food

Airline Meals

www.airlinemeals.net/

It might be hard to believe that a website dedicated to pictures of airplane food has grown to the point of having a cult-like following. Some 70% of its visitors drop by once or twice a day, according to an online poll. Remember airline food? Maybe only if you fly internationally. What started as a site with only a handful of pictures of various airborne meals now contains over 7,000 images, including a featured Meal of the Week photo. Lose time browsing the Q&A forum, where you can find answers to questions such as: What type of champagne does Air France serve? *Piper Heidsieck Brut non millésimé.* An interesting spin on the use of this site: Although created for simple entertainment, it is being used in one aspect of quality control among the airline catering companies. They look at the posted pictures and assess their work, making modifications when and where necessary.

Greener Education Materials

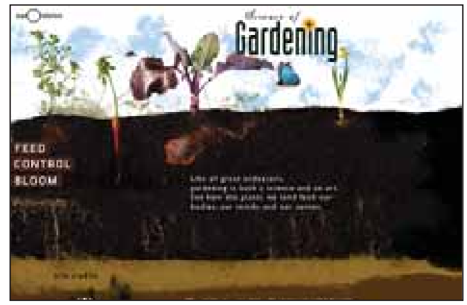


Green Chemistry

http://greenchem.uoregon.edu/gems.html

Brace for a bonanza of labs, lectures, syllabi, and multimedia presentations on green chemistry at this University of Oregon site. Funded by the National Science Foundation and supported by ACS, the university created a directory of classroom resources to promote green chemistry—the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances. Educators with their own green lesson plans and other ideas can contribute them to the site. It offers several ways to search for these green classroom supplements: by chemical topic, green chemistry principle, lab, audience, source, author, or chemistry subdivision. For example, seeking an alternative to the classic "Blue Bottle" introduction to the scientific process produces the resulting experiment, "Greening the Blue Bottle." The green method proposed in a *Journal of Chemical Education* article gives an alternative approach by substituting for the methylated organic compound.

Exploring Carnivorous Plants, Colorful Plant Sex, and Extreme Gardening



The Gardening Exhibit at the Exploratorium Museum

www.exploratorium.edu/gardening

Take a close look at the carnivorous Pitcher Plant as it entices insects with a sweet nectar that puts the insects in a drunken-like stupor, rendering them digestible prey. Or watch the jaw-like leaves of the Venus fly trap snap shut when the trigger hairs inside a leaf are stimulated. This is all part of a virtual stroll visitors can take through Peter's Savage Garden, featured in this online gardening exhibit of the Exploratorium. You can also visit Antarctica and learn more about hydroponics and subzero gardening, as well as see why this greenhouse is so important to the people in its community. Other links, such as Hello Dahlia, illustrate the colorful life of plant sex. This stylish, creative site provides three top-level links: Feed, Control, and Bloom. They form the framework to guide a more diverse audience than simply the home gardener to a fascinating, useful, and visually stimulating visit.

Advice about Electronics Technology

Computing & Technology Advice

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Don't miss these four powerhouse technology websites, which provide trustworthy advice, product reviews, news, the latest prices, downloads, RSS/XML feeds, and more. CNET targets the individual consumer with features like online courses, learning CDs, and Weekend Projects such as "Optimizing Your USB Drive." They also are known for their popular download.com site, which offers "safe, trusted, and spyware-free" downloads, *gratis.* ZDNET, part of the CNET network, is geared toward helping business professionals set IT priorities and make decisions, such as choosing high-quality vendors to solve a particular IT problem. They offer the largest database of IT white papers, with over 60,000 entries. *PC* is the only magazine that performs lab-based testing on technology products in order to provide the most comprehensive and accurate reviews for potential consumers. *PC World* magazine targets business managers and provides them with information to help them plan, buy, and use technology products optimally.

The Science of Spectroscopy

Wiki Spectroscopy

http://scienceofspectroscopy.info/wiki

Wikis are open forums, where anyone—but hopefully those with expertise—can add or edit text. The Science of Spectroscopy is a spectroscopy wiki. The entry on sunscreen chemistry, for example, that discusses two of the main UV-absorbing chemicals and how to determine effective SPF, is one of a number of discussions of growing applications posted on this site. Or collaborate with other chemists on spectroscopic techniques such as NMR and X-ray spectroscopy. The site enhances any student's understanding of light and matter with simple explanations of what happens when light and other electromagnetic radiation interact with matter. How, for example, do microwaves heat food? These waves have a certain energy that is sufficient to cause water and other polar molecules in food to rotate rapidly, thus heating the food. Another compelling component of the site is the partnership with NASA, which provides satellite and space images illustrating the uses of spectroscopy.

Kili Lay teaches chemistry at the Benjamin Franklin International School in Barcelona, Spain. She often uses Chem.WWW links as a resource to supplement the curriculum for her AP, conceptual chemistry, and other courses.

Quick Hits

"Where Science Meets Fiction"

www.technovelgy.com

Oh, what a wonderful site for science fiction fans, geeks, and patent lawyers to read about invention ideas from science fiction books and movies. Examples: carbon nanotube ribbons for space elevators; a Babelfish Necklace—an environmental translator for the visually impaired; and the smallest implantable body batteries, used to help patients with disabilities resulting from stroke and other conditions. Check out other "technology" content, such as lithocules, which are tiny intelligent building blocks.

Molecular Logic

http://molo.concord.org

Visualizing chemical equilibrium through an interactive Java application allows students to manipulate an equilibrium position by altering variables such as temperature. Teachers can find resources and references to standards and several popular textbooks in modules designed to help students visualize many biological, chemical, and physical processes on a molecular level. Java or Quicktime is necessary to run these guided explorations, but both are free through links directly from this site. Secondary-ed science teachers—check these modules out.

eBooks

www.manybooks.net

Download free books for that handheld organizer you can't leave home without. With close to 12,000 titles available, you can carry several books with you, and without the extra weight. Today's advances in PDA navigation and screen size make eBooks more enjoyable for many. And because the eBooks are on your PDA, which you never leave home without, you'll always have your book(s) handy when you find those unexpected free minutes.

Geologic Time by the Smithsonian Institute

www.nmnh.si.edu/paleo/geotime

Can you name any of the defining characteristics of the Triassic period? It marks the origin and rise of the dinosaur and is the start of life's incredible recovery from end-Permian extinction. Smithsonian Museum's interactive timeline allows you to learn about each eon, era, epoch, or period in geologic time. It includes links to evidence and foundational concepts, such as carbon dating and life processes. Rich with graphics, this site tells the story of the changing earth.

All About Graphite

www.phy.mtu.edu/~jaszczak/graphite.html

Homage to $C_{(graphite)}$ from a genuine graphite enthusiast, John A. Jaszczak, of Michigan Technological University. Proudly displaying plenty of pictures of graphite, such as spiral, floating, spherical, and conic forms, it also provides a reference page listing graphite's physical properties. View a historically celebrated sample of graphite from Burrowdale, England, famous for the amount and purity of the graphite found there. Jaszczak's site gives a nice boost to this slippery member of the carbon family!

From the Folks Who Wrote the Book… Er, the Program

http://support.microsoft.com/

So you try to connect your computer to a network, and get some mysterious error message like, "An operation was attempted on something that is not a socket." Get help with these and other problems from the folks who wrote the book, the program, and much more. Updated frequently, it is one of the year's ten best support websites. Find solution centers for all Microsoft products, downloads, and updates; search the knowledge base; and get self- or assisted support.

Genetics for the People

http://gslc.genetics.utah.edu

Gene therapy, stem cells, cloning, prions, or pharmacogenics—this tutorial helps make these complex subjects accessible to the high school student and beyond. Among its great classroom resources: How to Extract DNA from Anything Living (although they advise against trying this with your sister's toe). This site makes abstract concepts more concrete. Packed with illustrative images, helpful animations, and complete classroom modules, it is a must-use site for anyone teaching these topics!

Audiovisual Basic and Beyond

www.avsforum.com

Enhance, tweak, or even build your home entertainment setup with help from the audiovisual science forum experts. This forum facilitates posting questions and replies in different topic areas, such as the Home Entertainment and Theater Builder, Video Components, or Audio Area. You want to hook up a ten-seat theater with twenty-five watt base shakers? No problem for the folks at AVS Forum. You can even request decorating tips while you're at it!

Nano Hits

Trove of Trivia

http://dogman0.tripod.com/useless.html

Coconut milk can be used as a substitute for blood plasma! See the list of this and 154 other trifles!

The Art of Pen Spinning

http://www.pentrix.com

Learn how to spin your pen and be part of the growing online pen spinning community.

Armchair Arcade

www.armchairarcade.com

Video games and computers constitute this online magazine's forte.

Better Housekeeping

www.housekeepingchannel.com

Ideas and product reviews to master dust bunnies and household cleaning challenges.

Meta Search Engine from Amazon

www.a9.com

A personalized search engine with special features, such as saving notes on a search.

 BY CYNTHIA WASHAM

GENERAL READING TO BOOST A

Specialized Career

Newspapers, popular magazines, and other publications can be treasure troves of tips for advancing careers—no matter how specialized. And don't overlook The Chronicle.

Rod Stewart was spotted on a transcontinental flight reading that button-down, British weekly, *The Economist.* Sen. Hillary Rodham Clinton never misses an issue of the humor magazine *Funny Times,* and Donald Trump religiously reads seven newspapers a day. In addition to their specialty journals, most chemists read a hometown newspaper, *Chemical & Engineering News,* and maybe *Science.*

If you're looking for a job in the chemical sciences, you'll naturally turn to the standard sources such as *C&EN,* which offers career articles and a bonanza of job advertisements on its website (cen-chemjobs.org). It also has links to the ACS Department of Career Services (chemistry.org/careers), which provides a wealth of other resources, such as career consulting and resume reviews. However, those intent on climbing the corporate or academic ladder may want to add additional resources.

The pages of popular newspapers and magazines also contain gems for enhancing a career. There you might see an article about giving a presentation with poise or explaining how to ask for a raise. If you read women's fashion and fitness magazines, you'll learn how to handle the stickiest workplace issues, like the co-worker who sees the office as a swinging singles bar.

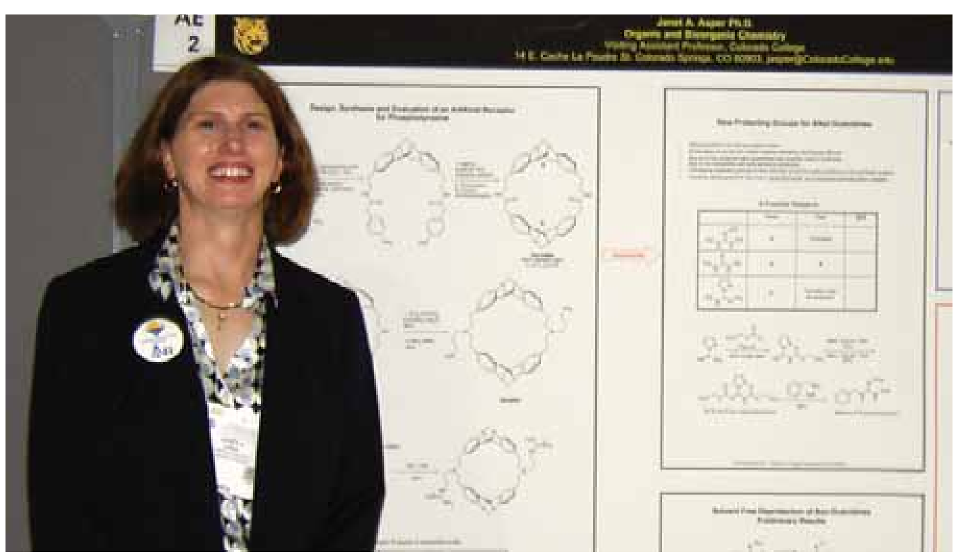
"I think most chemists love to read books," said Lisa Balbes (ACS '83), a self-employed consultant and technical writer from Missouri, "but reading business publications rarely occurs to them."

It hadn't occurred to her, either, until she found herself starting a business without a business background.

"Our professors groomed us to be professors," said Balbes, who holds a Ph.D. "We had no idea what other opportunities were out there and how to behave once we found them."

Balbes learned the ways of the working world by expanding her reading beyond science. Once she started reading *The Wall Street Journal,* she was hooked. She cherished the encouraging words in *Working Mother* when she started her business with a young child at home.

"It helped to read stories of other people and see that I wasn't the only one trying to do what I do," she said.



JANET ASPER (ACS '94)

Dress for Success

Chemists needn't be in the business world to reap the benefits of reading general career tips. Consider Janet Asper (ACS '94), an assistant professor of chemistry at the University of Mary Washington in Virginia. Asper spent the last three years as a visiting professor at Colorado College, where dressing for success meant putting on jeans and a casual shirt.

"At some schools," she confessed, "your faculty aren't exactly fashion role models."

When it was time to look for a new position, though, Asper knew what to wear from the career columns she'd read in *The Wall Street Journal.* Her more formal look helped her to feel more professional and confident during interviews, and it paid off with her new job at Mary Washington.

If you'd rather do your reading online, you're in luck. Periodicals that feature career advice often put just as much information, and sometimes more, on their websites. *The Wall Street Journal's* Executive Career Site features ten columnists. They advise on every imaginable workplace situation, from boosting your performance on business trips to keeping mum about delicate personal matters at work. The "Who's Hiring" section enables browsers

to check out job listings at major corporations. Job seekers also can post their résumés on the site.

For anyone in academia, *The Chronicle of Higher Education* is a must read. It's packed with listings of faculty positions and articles about how to get them.

"We try to look at academic culture," said Denise Magner, senior editor of *The Chronicle's* careers section. "We try to offer inside experiences. We might have a story on what it's like to be a new faculty member on a tenure track, and one on what it's like to be denied tenure."

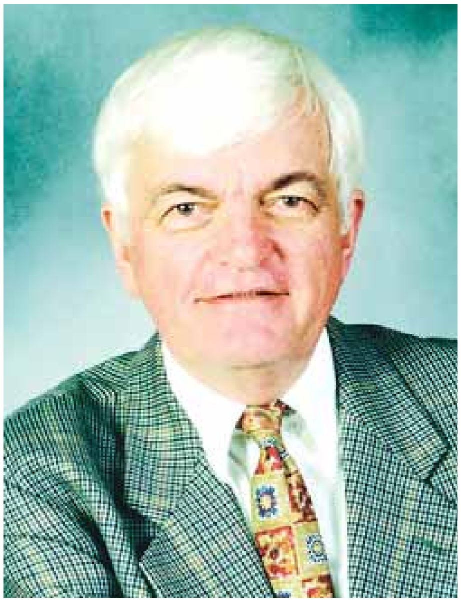
The Chronicle is as relevant to new faculty members as it is to Douglas C. Neckers (ACS '59), who has spent more than 40 years navigating the corridors of academia.

"I read it now for information about what to do if I were to retire," said Neckers, executive director of Bowling Green State University's Center for Photochemical Sciences.

Professional Development Emphasis

Other magazines that can help strengthen career skills include *Money, Forbes,* and *Fortune.* The cover story on the September 2005 edition of *Money* showcased information about how readers can ditch the 9-to-5 grind and work for themselves. That same month, *Forbes* featured its list of top MBA programs for part-timers. Competing

LISA BALBES (ACS '83)



DOUGLAS C. NECKERS (ACS '59)

Fortune provides an enlightening exposé of identity thieves who prey on job seekers who've posted their résumés on Internet job sites.

Unlike the chemists that Balbes was talking about when she said most never think of reading business publications, Henry Blount does pays attention to newspapers and magazines with a business focus. However, he does not read them for career tips that he can personally apply in changing jobs.

After 23 years with the National Science Foundation, Blount is settled and content in a challenging and fulfilling position.

Yet he has no doubt his younger peers will benefit from looking beyond professional journals for career advice.

"The chemistry profession doesn't do enough professional development as an integral part of the educational process," he said. "We should place more emphasis on it during the early training of chemists, just as the ACS does in so many ways for its membership." ⬢

Cynthia Washam's research on this column made her into an avid reader of professional development articles. Chemistry's *regular CareerView columnist, Washam is a freelance writer in Jensen Beach, FL., where she lives with her husband and son.*

Sampler of Publications with Career-Enhancing Sites

www.cenjobs.org

CEN-CHEMJOBS is the classifieds and careers site of *Chemical & Engineering News,* with tools, resources, and expert career advice to help new and experienced chemists reach their professional goals. It accommodates both individuals seeking jobs and employers with jobs to offer. Also, don't miss the links to other ACS career resources, most notably, the ACS Department of Career Services.

chemistry.org/careers

The ACS Career Services website includes a wealth of information to assist chemical professionals in managing their careers.

www.CareerJournal.com

The Wall Street Journal's Executive Career Site is packed with well-written and well-researched columns on everything from finding a job to planning for retirement. Visitors can search for jobs, check out sample résumés, post résumés, even join lively discussion groups.

http://chronicle.com

Job listings on *The Chronicle of Higher Education's* website are required reading for anybody looking for a job in academia. Thought-provoking, unpredictable career columns are written by academics about their own experiences. Chatty visitors can participate in a half dozen career forums.

www.WorkingMother.com

The website provides the venue for this magazine's popular 100 Best Companies list. *Working Mother* bases its annual ranking on family-friendly benefits such as on-site day care, generous maternity leave, and flexible hours.

—CW

And the Winner Is...

Students in SA chapters around the country polish their communication skills by writing annual reports. ACS uses the reports to make awards to outstanding chapters.

Student Affiliates performed demonstrations at local science museums, led hands-on activities at elementary schools, and hosted a bake sale during National Chemistry Week—complete with a periodic table of cookies and cupcakes.

Those were just a few of the activities performed by Student Affiliates chapters during the 2004–2005 academic year and described in annual reports. On the basis of those reports, the American Chemical Society's Committee on Education selected 32 "outstanding," 62 "commendable," and 82 "honorable mention" chapters that will receive plaques during the 231st ACS National Meeting in Atlanta on March 26, 2006.

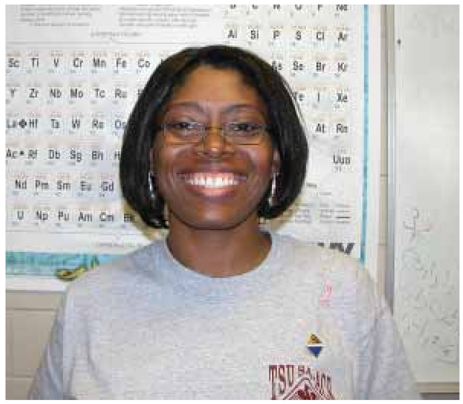
For a complete list of chapters receiving honors, see chemistry.org/education/saprogram.html.

Chapters are required to submit a report at least once every three years to maintain active status. Those just interested in keeping that status only need to fill out information sheets and a table listing the Student Affiliates. But those hoping for an award must complete the entire form.

Writing Those Reports

It takes work, but writing the reports helps future chemists hone skills. "Student Affiliates are learning how to prepare reports that highlight their activity and how to follow report guidelines"—important abilities when applying for jobs or grants, said LaTrease Garrison (ACS '98), senior education program manager at ACS.

Tracey Willis, a reviewer and the chapter adviser at Texas Southern University in Houston, said writing the annual report "stressed to the students the importance of being organized and maintaining adequate records." The TSU chapter, revived after several years of dormancy, celebrated a full year of activities in May.



TRACEY WILLIS

TSU's report described activities such as celebrating National Chemistry Week for the first time and participating in an on-campus health and wellness fair by offering information about the importance of chemistry in biological systems. The chapter also held professional development workshops on topics such as "Finding an Internship" and "How to Prepare an Outstanding Resume." TSU was selected as a commendable chapter.

Fourteen reviewers—all faculty advisers to SA chapters—met in Washington for three days in July to comb through the reports, each of which already had been read by a reviewer from outside ACS. The Washington group split into two-person teams to read and discuss the entries and compare their conclusions with those of the original reviewers.

MICHAEL B. MCGINNIS (ACS '91)

The most common disputes arose over how activities should be counted or how much time those activities consumed, says Michael B. McGinnis (ACS '91), one of the reviewers and chapter adviser at Georgia College & State University, which received an honorable mention award. The impact and scope of the activity also are typical topics of debate.

Adding Up Achievements

Reviewers check that activities are not double counted in multiple categories, factor in the size of the school when evaluating student participation, and consider how much dedication activities required. Two students setting up a booth at a mall for half an hour would not merit as much recognition as a club that brings 15 people to a mall for half a day or more to lead activities and perform demonstrations, McGinnis says.

McGinnis added that writing the reports not only sharpens record-keeping skills, but also teaches students to delegate: Student Affiliate presidents must tap other members to get the job done. And the reports give students a chance to reflect on their success. He continued, "When they start putting it on paper, they realize truly how much they have done over the entire year." ⬢

Rachel Smolkin is a freelance writer in Washington, DC, and a regular contributor to Chemistry. *In addition to being our regular Student Affiliates columnist, she wrote recent* Chemistry *features on global outsourcing and other topics.*

Living the Healthy Life IN CHEMISTRY

B Y JOAN STEPHENSON

Job-related illnesses and deaths are rare in chemistry, and chemists generally are a healthy and long-lived group. However, chemists do run certain health risks.

In August 1996, as Karen Wetterhahn transferred highly toxic dimethylmercury from one container to another, she spilled a drop or two onto her latex-gloved hand. A few months later, the Dartmouth College chemistry professor's speech became slurred and her gait unsteady. Tests revealed that her body contained more than 80 times the lethal dose of mercury. Shortly thereafter, Wetterhahn lost her vision, hearing, and speech; slipped into a coma; and died. Studies later determined that the compound had apparently passed through her latex glove and her skin, unseen, within seconds.

To be sure, work-related deaths among chemists are rare—none were reported for chemists in 2003, for example, according to the most recent available data from the Occupational Safety and Health Administration (OSHA). But such tragedies underscore the fact that chemists' work environments can pose serious health risks.

Live Long and Prosper?

How do chemists fare in terms of living a long and healthy life? Data about life expectancies of chemists are limited. In their 1969 book *Man,* anatomist Richard J. Harrison and primatologist William Montagna featured a table listing the "average longevity of eminent men in various occupations." The average age at death of chemists in this vaguely defined group was 69.8 years, somewhat older than botanists (68.4 years) and mathematicians (66.6 years) but younger than geologists (70.1 years) and entomologists (71 years). All live considerably longer than hereditary European sovereigns (49.1 years).

Just how meaningful these data are is debatable (Harrison and Montagna don't indicate a source), but these lifespans are not radically out of line with those of the U.S. population during that era: 66.8 years in 1969 for men in the United States, according to the National Center for Health Statistics. With advances in medicine over the past three decades, however, life expectancies for the population as a whole, including chemists, has never been higher: 74.8 years for men and 80.1 years for women.

Even though chemists appear to fare as well as or better than the average person in terms of longevity, they are not immune to work-related illness and injury. In 2003, according to OSHA, chemists sustained about 150 injuries or illnesses that required one or more days away from work, with "chemicals or chemical substances" classified as the reason in about 40% of these cases.

"Most injuries we're aware of are acute," said Joseph Passante (ACS '94), a certified industrial hygienist at the University of Pennsylvania and a member of the American Industrial Health Association's (AIHA's) Laboratory Health and Safety Committee. In addition to thermal and chemical burns, common injuries include wounds from imploding glassware or reaction vessels and eye injuries from UV light.

Overlooked work-related illnesses that chemists may face include repetitive stress injuries and allergic reactions, said Robert Sussman, a toxicologist and member of AIHA's Workplace Environmental Exposure Levels Committee. For example, chemists handling potent pharmaceutical compounds in poorly designed isolators or who are shaking separation funnels or repeatedly pipetting for long shifts may suffer musculoskeletal stress. Allergic reactions to a chemical compound are also not uncommon among chemists working in

JOSEPH PASSANTE (ACS '94)

the pharmaceutical industry. These reactions are particularly important because once an individual becomes sensitized to a specific compound, subsequent exposure to much lower quantities of the same material can cause a severe, even potentially fatal, allergic response.

Long-Term Health Effects

Harder to track than acute injuries are the long-term health effects of work-related exposures, some of which emerge years later. While findings detailed in the medical literature since the late 1960s differ from study to study, certain trends have emerged.

One seminal study was published in 1969 in the *Journal of the National Cancer Institute.* It examined causes of death among 3,637 male members of the American Chemical Society, most of whom were white and died between 1948 and 1967. Compared with professional men in general, male chemists had a significantly higher proportion of deaths from cancer. Nearly half of the "excess" cancer deaths were due to malignant lymphoma (cancer of the lymphatic system) and pancreatic cancer. Chemists aged 64 and older also were more likely to die of leukemia compared with nonchemists in the same age range.

Female ACS members were more likely to die of breast cancer compared with the U.S. white female population as a whole. But the researchers pointed out that 40% of the 115 women in the sample were unmarried and had a high socioeconomic status, factors generally linked with an increased risk of breast cancer.

Perhaps more troubling was the finding that 11% of the female ACS chemists died by suicide, a rate 5 times that of the U.S. white female population. A 1985 study of causes of death among 347 white female ACS members confirmed this figure, and also found an elevated risk for cancers of the breast, ovary, stomach, and lymphatic and hematopoietic (blood-forming) systems. Increased suicide risk has been documented among professional women in other occupations, particularly physicians. The reasons are unclear, but researchers speculate that having access to lethal chemicals in their work environments might be a factor. The female chemists' method of choice was cyanide.

Authors of a 1992 analysis of several epidemiological studies of chemists and other laboratory workers reported similar findings regarding increased mortality from leukemia and cancers of the lymphatic and hematopoietic systems. Anecdotal data suggested that benzene and other solvents could at least partly explain the increase in these cancers among chemists, they said. They also noted that several studies suggested a link between lab work and adverse reproductive effects in women, including miscarriages and birth defects.

In addition to elevated numbers of deaths due to lymphatic cancers and leukemias, a 1993 study examining the mortality of 4,012 chemists in England and Wales who were followed for 25 years (1965 to 1989) also found significantly increased rates of deaths from mental disorders and neurological diseases and somewhat higher than expected deaths due to intestinal cancer, pancreatic cancer, kidney cancer, and malignant melanoma. Other studies have found that laboratory scientists may have somewhat elevated risks for cancer of the brain, colon, bladder, and prostate, as well as for certain gastrointestinal cancers.

Balancing It Out

Chemists can take heart from other findings, however.

Studies also suggest that compared with the population as a whole (after adjusting for age), chemists have a lower mortality rate in general, a lower mortality rate from cancer overall (and from lung cancer in particular), and are less likely to die of cardiovascular disease, respiratory disease, or cirrhosis of the liver.

In part, this is likely due to the "healthy worker effect:" People who are able to work are healthier than the proportion of the general population that is too sick or disabled to work. In addition, chemists may have another factor on their side: intelligence. A large study of a population in Scotland suggested that people with higher IQs were more likely to live longer and less likely to die from cancer and heart disease than those with lower IQs—perhaps because intelligence represents learning,

Occupational Hazard for Nobel?

Did work sicken nineteenth century Swedish chemist and dynamite inventor Alfred Nobel and hasten his death at age 63? Based on descriptions of Nobel's condition (he suffered from depression and anginal pains) and work habits (which included prolonged experimentation with explosives), the author of a 1997 article in the journal *Medical Hypotheses* speculates that nitroglycerine poisoning was an aggravating factor that contributed to the inventor's deteriorating health and early death (Kantha, S.S. *Medical Hypotheses. 1997, 49,* 303–306).

—JS

reasoning, and problem-solving skills that can help individuals adopt health-promoting behaviors and enable them to stick to complicated treatment regimens. Indeed, researchers found that while IQ was not associated with initially taking up smoking, people in the study population who had higher IQs were more likely to have quit by 1970, after the health risks had become known.

Safety First

Studies of chemists and potential cancer risks published to date are largely a snapshot of the health effects caused by exposures decades earlier. Are chemists today encountering the same level of hazard as those who were the subjects of past studies?

"Chemists are certainly better informed now and are certainly safer," said Sussman. Laboratory engineering and work practice controls implemented in the past couple of decades to address OSHA standards have also substantially reduced occupational risks.

On the other hand, novel hazards can emerge that necessitate new safety procedures and equipment. For example, nanotechnology research is forging ahead despite the fact that the potential health risks of exposure to nanoparticles are unknown. (Animal studies suggest that these tiny particles can pass through lung tissue and travel through the circulatory system to other organs, or make their way from nasal tissue up the olfactory nerves and into the brain.) "We'll just have to wait and see," said Passante.

Whatever the potential hazards, chemists need to take an active role in identifying and dealing with health risks, Passante noted. "Any professional working as a chemist should take to heart that they have to take responsibility for their own safety." Such responsibility involves understanding how to do a basic risk assessment of the potential hazards of a material and adopting the necessary precautions, such as choosing the right type of personal

ROBERT SUSSMAN

protective gear and carrying out the work under appropriate conditions, such as under a fume hood or inside a glove box.

In the overall scheme of things, however, occupational hazards are dwarfed by other risk factors in their impact on human health. According to researchers at the Centers for Disease Control and Prevention, more than 40% of deaths in the United States in 2000 were caused by behaviors we have some control over, such as smoking, poor diet, physical inactivity, and alcohol consumption.

By addressing these behavioral risk factors, one can substantially raise the odds of living a longer and healthier life. Beyond this, chemists can tackle their own particular occupational risk factors by taking appropriate precautions.

"There are very few chemicals that can't be handled safely after a proper evaluation of their hazards, the use of appropriate personal protective equipment, and proper training in the use of ventilation, engineering controls, and other equipment," said Sussman. ⬢

Joan Stephenson, Ph.D., is an award-winning science and medical writer based in Chicago.

Lab Safety Resources for Chemists

The American Chemical Society's Division of Chemical Health and Safety maintains a website with links to laboratory safety training opportunities and to information about the monthly journal, *Chemical Health & Safety* (http://membership.acs.org/c/chas/).

The American Industrial Hygiene Association's Laboratory Health & Safety Committee website provides comprehensive information about laboratory safety (www2.umdnj.edu/eohssweb/aiha/administrative/design.htm).

The National Library of Medicine's Toxicology Data Network (ToxNet) provides access to a cluster of databases about toxicology, hazardous chemicals, and related areas (www.toxnet.nlm.nih.gov).

The Howard Hughes Medical Institute's Office of Lab Safety has a range of materials to educate researchers about how to incorporate the fundamental rules of safety into their work routines, including an online safety course, laboratory chemical safety summaries, emergency response guidelines, and a catalogue of free lab safety training videos produced by the institute (www.hhmi.org/about/labsafe/).

Free online access to *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals,* one of the most important manuals in the field of laboratory chemical safety, is available at http://books.nap.edu/catalog/4911.html.

—JS

A HAPPY NEW YEAR

for Retirement Planning

BY KERRY J. SCAFELLA

January's mail brings that inevitable greeting from the IRS, making it time for strategies that can reduce your 2005 federal tax bill while building a retirement nest egg.

Mention a 401(k), and most people think of the retirement plans that have become fixtures for employees of big companies. Employees make contributions through payroll deductions, building a retirement nest egg while reducing their adjusted gross income (AGI) and federal income tax bill. Some get a bonus from employers who match all or part of the contribution. More and more, 401(k)s are taking the place of traditional pension plans, which the corporate world is dropping to cut costs.

Individuals who run small or sideline businesses, including chemists and chemical engineers who consult part-time, may be surprised to discover that they can start a special kind of 401(k) and benefit greatly. So-called individual or "solo" 401(k)s are available for business owners with no employees other than co-owners or spouses. That's right. As a small business owner, you can now enjoy the same 401(k) retirement plan benefits currently provided to millions of other Americans.

If you got a late start on retirement savings and retirement is approaching, saving as much as you can often becomes a prime concern. In such cases, a one-person 401(k) may be an appropriate choice for you. With a one-person 401(k) you can make profit-sharing contributions of up to 25% of your compensation for incorporated businesses or 20% for unincorporated businesses, subject to a $210,000 compensation cap in 2005. Plus, you may make an additional $14,000 salary-deferred contribution, and if you are over age 50, that amount increases to $18,000.

The combination of profit-sharing and salary-deferred contributions for 2005 may not exceed $42,000 ($46,000 if you are age 50 or older). For many business owners, a 401(k) allows for larger annual contributions than the Simplified Employee Pension, or SEP IRA, the most familiar self-employment retirement plan.

The one-person 401(k) plan can make saving for retirement easier. Some fully self-directed plans, for example, may allow for a wide range of investment opportunities including stocks, bonds, and mutual funds; provide a loan provision; and allow you to transfer other retirement accounts including Keoghs, SEP IRAs, and traditional IRAs (excluding after-tax balances) into your one-person 401(k) account.

Spousal IRAs: A Savings Plan That's Twice as Nice

Consistently funding an IRA with $4,000 every year is a reliable way to build a retirement nest egg. Saving $8,000 a year, of course, would be twice as nice. Married couples can do exactly that, even if only one partner has earned income. For 2005, married couples with at least $8,000 in earned income can each have an individual IRA and contribute $4,000 to it, thereby benefiting from tax-deferred savings for retirement and possibly for other financial goals as well. Don't overlook changes in tax law that allow additional "catch-up" contributions for individuals who are over age 50. For the 2005 tax year, they can contribute an extra $500. The catch-up contribution increases to $1,000 in 2006, for a total contribution of $5,000 per individual.

Spousal IRAs are a way for the nonworking spouses of wage earners to put aside funds for their futures. Contributions made to a spousal IRA belong to the nonworking spouse even if contributions came from the wage-earning spouse. If you were married by December 31, 2005 and neither you nor your spouse made a contribution for 2005, you have until April 14, 2006 to do so. If you don't have an IRA, you can still start one by April 14 and get the 2005 tax deduction if you are eligible.

For 2005, the deductibility of one spouse's contribution no longer depends on whether the other spouse has an employer-sponsored retirement plan. If one spouse works and is not covered by a retirement plan, for instance, then his or her contribution is fully deductible as long as the couple's AGI is under $150,000. The same is true if the spouse is not earning income at all. Once the couple's joint AGI exceeds $150,000, however, partial deductibility begins.

The 2005 deductibility limits of IRA contributions for married couples who file jointly and who both have retirement coverage at work have been increased. Fully deductible contributions for both spouses occur if AGI is below $65,000 and phases out when the AGI reaches $80,000. These phase-out limits will continue to increase to $85,000 in 2006 and reach $100,000 by 2007.

Choosing to fund your 2006 contribution early (even though the 2006 contribution can be made until April 15, 2007) would mean starting off 2006 with a grand total of $16,000 in contributions, or $19,000 if both spouses are over age 50. That's an excellent strategy, too, because you earn extra interest by making the investment early each year.

Roth IRA Q&A

Q: What is the Roth IRA?

A: As a savings alternative to the traditional IRA, the Roth IRA provides the opportunity to invest your after-tax dollars, benefit from tax-deferred growth, and—most importantly—receive tax-free distributions at retirement. A Roth also gives investors greater flexibility to use their retirement assets to help fund intermediate- to long-term goals, such as first-time homeownership and higher education, as well as a comfortable retirement.

Q: Who is eligible to open a Roth IRA?

A: It depends solely on your level of earned income or that of your spouse. In 2005, if your adjusted gross income (AGI) is below $95,000 (for an individual return) or $150,000 (for joint returns), you can make the full annual contribution of up to $4,000 or 100% of earned income, whichever is less. Partial contributions are permitted for individual-return filers whose AGI is between $95,000 and $110,000 and joint-return filers whose AGI is between $150,000 and $160,000. An additional $500 "catch-up" contribution is permitted for individuals age 50 and older.

Q: Are there advantages to a Roth IRA?

A: Two major pluses: There is no age limit on who can contribute to a Roth IRA, and participation in an employer-sponsored retirement plan has no impact on contributions to a Roth IRA.

Q: Are contributions to a Roth IRA tax deductible?

A: No. All contributions to a Roth IRA are nondeductible, regardless of income.

Q: How are distributions from a Roth IRA taxed?

A: One of the great benefits of a Roth IRA is that your money isn't tied up, because you may withdraw your contributions at any time without tax or penalty. Withdrawals of accumulated earnings on your Roth IRA contributions are tax- and penalty-free if held for five years or more and any one of the following conditions applies:

- over age 59½,
- used for first-time homeownership ($10,000 lifetime limit),
- disability, or
- distribution to beneficiaries upon IRA holder's death.

Ordinary income taxes are due when

- one of the above situations occurs, but the account is open less than five years;
- used for qualified higher education expenses incurred by the IRA holder or an immediate family member;
- used for medical expenses exceeding 7.5% of AGI; or
- used for health insurance after receiving unemployment compensation for more than 12 weeks.

Ordinary income taxes and a 10% penalty are due when accumulated earnings are withdrawn for any other reason.

Q: What happens when you convert a traditional IRA to a Roth IRA?

A: Income and tax considerations arise when you convert a current traditional IRA to a Roth IRA. First, your AGI must be $100,000 or less (filing jointly or singly) to be eligible for a conversion. If you are married, you must file jointly. Second, the taxable amount of the converted funds (from earnings and deductible contributions) is subject to ordinary income taxes, but no penalty, in the year of conversion. Converted funds must remain in the Roth IRA for five years from the conversion to receive the favorable tax treatment on distributions. Any distributions from a Roth Conversion IRA before the five-year holding period ends will be subject to a 10% penalty.

—KS

Roth IRAs

Married couples filing jointly whose AGI is under $150,000 are eligible for full contributions to a Roth IRA. Couples with AGIs up to $160,000 can take partial contributions. The limits on Roth contributions are the same as for a traditional IRA—$4,000, or $4,500 for those age 50 and over. Contributions to Roth IRAs are not tax-deductible. However, distributions are tax-free for individuals who have had the Roth for at least five years and make withdrawals after age 59½. Tax-free distributions of up to $10,000 from a Roth IRA may be used for the purchase of a first home. Distributions for qualified higher education expenses are penalty-free. Contributions may be withdrawn tax- and penalty-free at any time.

All IRAs allow annual contributions and tax-deferred growth. However, complexities arise with respect to who can establish these accounts, as well as the tax implications of distributions. The Roth IRA, created by the Taxpayer Relief Act of 1997, has many investors asking about its potential tax and retirement planning benefits. Some of the most common are highlighted in the Q&A sidebar accompanying this article.

IRAs and one-person 401(k)s can make saving for long-term goals, such as retirement, a realistic family activity. Your financial adviser can help you decide which IRA is suitable for your individual situation and can provide additional information about the features and benefits of both the traditional and the Roth IRA. ⬢

Kerry J. Scafella (kerry.j.scafella@smithbarney.com) is a financial consultant with Smith Barney in Washington, DC. Smith Barney does not provide tax or legal advice. Please consult your own tax and/or legal adviser for such guidance.

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SOME OF THE

Great Teachers of Chemistry

To launch a discussion and a planned national meeting symposium, *Chemistry* looks at a few individuals noted for quality in the classroom. We're making a list and asking readers to submit names of their own greatest teachers and what made them great.

BY RACHEL SMOLKIN

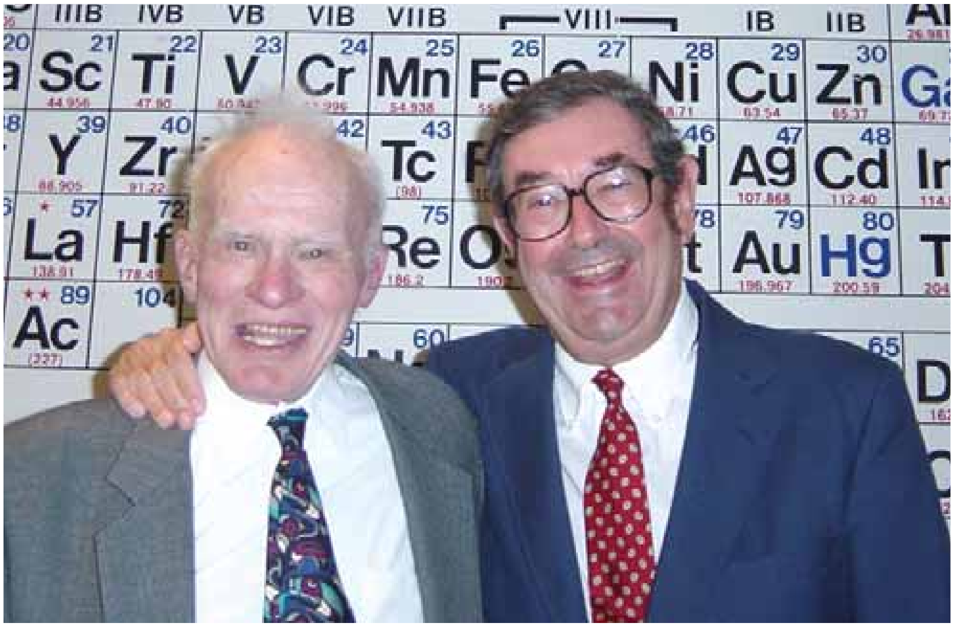
A leopard costume, a Richard Nixon getup with a prominent nose, and a King Feisal outfit were among the greats. But the horse was his favorite.

"The first time I dressed up as a horse was a great moment," recalled Harry Gray (ACS '59), a legendary chemistry professor at the California Institute of Technology. "The students didn't know what was going on at first, and then I took off the horse head and they saw it was just me. It was a whole outfit. They went wild and broke into wild applause."

The horse originated as retaliation in the early 1970s. Gray's students had secretly redecorated his office as though it belonged to the famed French chemist Antoine Lavoisier, necessitating a madcap response: a horse, of course. It quickly became a trademark of sorts, and Gray even played Harry the Horse in Caltech's version of the musical *Guys and Dolls.*

Unorthodox costumes say a lot about Gray's sense of humor and, more importantly, about his approach to teaching. "It's ridiculous to try to lecture in a horse outfit, but you can do demos and fun things," he noted. "You've got to have their attention. They've got to be in class. They've got to like you and be with you, and then they've got to be willing to work at it. Chemistry is hard."

Enthusiastic chemistry teachers like Gray can make learning easier and inspire students to pursue chemistry as a career. They serve as role models and mentors, challenging students in class, inviting them into research groups, guiding their



BRIAN LEIGH (ACS '00)

GEORGE HAMMOND (LEFT) AND HARRY GRAY (ACS '59)

discoveries, and interacting with them one on one. Many great teachers not only inspire future chemists, but also enliven science for nonchemists by teaching introductory courses, writing books, and shaping high school and undergraduate curricula. The ACS has honored dozens of great teachers and great mentors with national awards (chemistry.org/awards) over the years. And the ACS Division of Chemical Education (http://divched.chem.wisc.edu/) is the global leader in efforts to advance the teaching and learning of chemistry. The ACS Education Division, under the auspices of the Society Committee on Education, provides professional development opportunities for K–12 teachers and products and services to support chemistry literacy among undergraduate students (chemistry.org/education).

The late George C. Pimentel of the University of California, Berkeley, exemplified these qualities, and the American Chemical Society offers a chemical education award in his name. Pimentel cherished his lectures to freshmen as much as his hours training doctoral students. He edited and helped write *Chemistry: An Experimental Science,* a textbook published in 1960 that emphasized learning through performing experiments, making observations, and drawing conclusions. The book was adopted in high school classrooms across the United States and in many other countries.

Pimentel also coauthored a freshmen chemistry textbook in 1971 called *Understanding Chemistry* that demonstrated his grasp for colloquial language as well as scientific concepts. "George had an affinity for the way the kids were talking and speaking," said Charles B. Harris, dean of chemistry at Berkeley. "If you read his book, it has that quality to it."

IOWA STATE UNIVERSITY

GREG GEOFFROY

Gray's colleague George S. Hammond, the pioneering photochemist who died in 2005, is another legendary teacher. Not only did his own students launch the modern discipline of organic photochemistry, but he strove for a broader impact on organic chemistry with a renovated curriculum that became known as the Hammond curriculum. He and the late Donald Cram, a chemistry Nobel laureate at the University of California, Los Angeles, wrote a popular 1959 organic chemistry textbook that reorganized the presentation of organic chemistry.

Lesser-Known Legends

For every one of the legendary teachers like Gray and Hammond, there are countless others who get less recognition. "There are great chemistry teachers everywhere, at small liberal arts colleges, community colleges, big universities," said Gregory L. Geoffroy, president of Iowa State University and a chemistry professor himself. Geoffroy completed his doctoral dissertation at Caltech under the tutelage of Hammond and Gray and drew inspiration during his undergraduate days from Thomas Crawford at the University of Louisville in Kentucky. He cites Ohio's Oberlin College and Minnesota's St. Olaf College among the liberal arts schools with excellent reputations in the teaching of chemistry.

Berea College in Kentucky has for decades enjoyed an outsized reputation for its chemistry teachers, who have been instrumental in training and inspiring Appalachian students to pursue careers in science. Among the luminaries who studied there is John B. Fenn (ACS '41), who won the 2002 Nobel Prize in Chemistry. Fenn studied freshman chemistry with the late Julian Capps, one of Berea's teachers renowned for his commitment to students and his ability to enliven his subject.

While university professors often receive more laurels and enjoy greater name recognition in the field, their counterparts in high schools create the foundation for students' success.

Students don't pursue chemistry in college if they aren't excited about it in high school, noted Annis Hapkiewicz, who has taught chemistry at Okemos High School in Michigan for 30 years. Hapkiewicz, who won the 2005 ACS James Bryant Conant Award in High School Chemistry, tries to help her students appreciate the beauty of her subject.

"For beginning students, the periodic table is very exciting because once they realize how much they can do with the periodic table and the basic principles it illustrates," Hapkiewicz pointed out, "they have some feeling that they can figure it out for themselves."

The dedication of great teachers has inspired generations of U.S. chemists. "Many American organic chemists recall with great warmth their years postdocing with Harvard's Robert Burns Woodward," said Mary Ellen Bowden, senior research historian at the Chemical Heritage Foundation. Former student Don Cram wrote that Woodward "personified" scientific excellence.

Another Harvard luminary is the late George Wald, a biochemist and Nobel Prize winner featured in a 1966 *Time* magazine cover story as one of the nation's 10 best teachers. *Time* made the selection after a year-long reporting project that sought the guidance of faculty deans, foundation experts, education specialists, and students.

The article quoted the *Harvard Crimson* newspaper lauding Wald's "Nat Sci 5" as "one of Harvard's truly great courses." It described how Wald mesmerized his 400 students on a journey that began with protons in the fall and ended with living organisms in the spring. Wald told the magazine that facts are "just raw material for understanding basic relationships, and the whole job of teaching is to weave a fabric of relationships and to attach this at so many points to the student's life that it becomes a part of him."

Inspiring Diversity in Chemistry

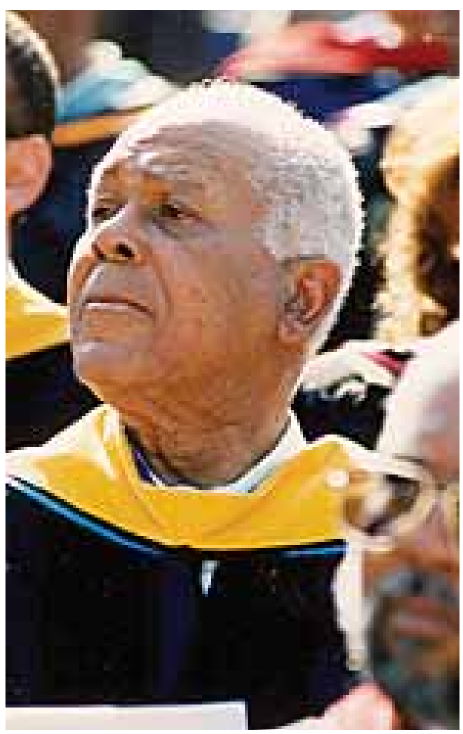
Some chemistry teachers are celebrated for broadening the reach of the sciences and diversifying the field of chemistry. Emma Perry Carr made Mount Holyoke College in Massachusetts "a powerhouse in producing women chemists early in the twentieth century," Bowden said. "In the early days, before the 1970s, there were always a few men who happily mentored women students," Bowden pointed out. Among them were Penn's electrochemist, Edgar Fahs Smith, and J. D. Bernal, the English X-ray crystallographer. Bernal's students included chemistry Nobel laureate Dorothy Crowfoot Hodgkin.

At Morehouse College in Atlanta, Henry C. McBay inspired hundreds of African-American scientists. Forty-five of his graduates at Morehouse went on to earn Ph.D.s in chemistry. Before McBay's death in 1995, a symposium in his honor at the Massachusetts Institute of Technology credited him with motivating more African-Americans toward Ph.D.s in chemistry than anyone in the nation, said Morehouse College President Walter E. Massey, one of McBay's former students.

Massey, a physicist and former director of the National Science Foundation, took freshman chemistry from McBay in 1954. McBay had meticulous presentation and rigorous standards. "He taught his students what it means to be excellent," Massey said, and prepared them to go to the best graduate schools in the country.

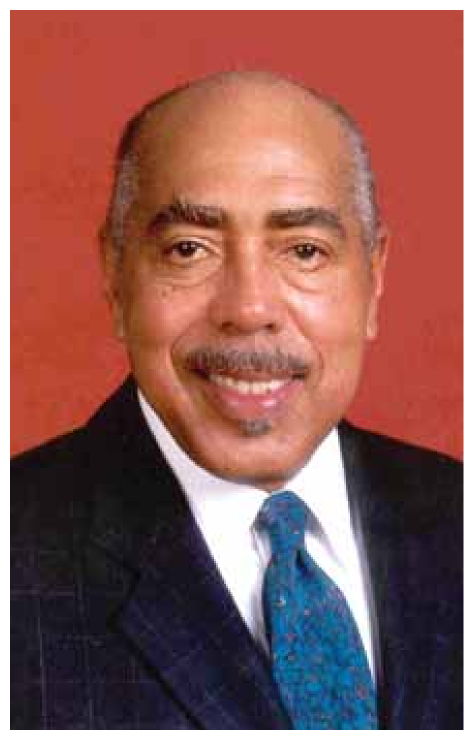
"The joke at Morehouse during that period was McBay was responsible for more

ANNIS HAPKIEWICZ



MOREHOUSE COLLEGE

HENRY C. McBAY



MOREHOUSE COLLEGE

WALTER MASSEY

students going into the ministry than the professors of religion because they all flunked chemistry," Massey said, adding the serious note that his former professor worked with students who needed extra help.

McBay used humor in the classroom almost as skillfully as Harry Gray. Massey remembers how he would carefully write very long equations on the blackboard. Sometimes in the afternoons students would doze off in the hot classrooms that had no air conditioning. "We'd try to wake them up," Massey recalled. "And he'd say, 'No. No, don't wake him up. He's a future genius. He can absorb it all.'"

Great teachers can continue to influence their students decades after they have left campus. McBay, for instance, was on the search committee that brought Massey back to Morehouse as president in 1995. "He reminded me what Morehouse had done to prepare me for my career," said Massey, who also is a former director of Argonne National Laboratory. "He didn't say this, but he reminded me that I would not have achieved what I had achieved in life without Morehouse."

What Is Great Teaching?

At its core, great teaching is epitomized by a gift for inspiration and a willingness to interact with students as individuals outside the classroom. Gray and Hammond personified these qualities, according to two of their former doctoral students who have gone on to lead major universities.

"Both of these great people were informal in interacting with their students and didn't let their high accomplishments and the recognition they had received get in the way of great human interactions," said Mark S. Wrighton (ACS '69), chancellor of Washington University in St. Louis. "I was treated as a junior colleague—junior, to be sure, but nevertheless I was valued as a contributor."

Gray and Hammond nurtured their students by allowing them the freedom to try—and to fail—in their research. "They provided important supervision when necessary and also encouraged a degree of independence which would enable me to make my own mistakes and come back thereafter and get the guidance needed to get it right," Wrighton said.

JOE ANGELES/WUSTL

MARK S. WRIGHTON (ACS '69)

Iowa State University's Geoffroy offered a similar assessment of his mentors. He termed Hammond a "world-class scientist who also had that knack of inspiring his students."

Gray was a "great graduate mentor" who would visit the cramped graduate students' office with a cup of coffee in his hand and swap ideas. "His approach was not to give us day-to-day guidance. His approach was to gather around very talented young people and provide that stimulating environment that let each of us develop our own ideas and directions," Geoffroy said.

As a classroom teacher, Gray was "just awesome," Geoffroy said, citing a flair for enlivening every subject. "Through a whole semester, he might just have a couple pages of notes. He knew everything and presented it in a clear way that just drew you into the material."

Teaching Like Kinstle

The best chemistry teachers go the extra mile in encouraging their students to achieve, expecting and receiving excellence from their pupils in exams and coursework. Thomas Kinstle (ACS '58), a chemistry professor at Ohio's Bowling Green State University, is one such teacher.

"The 'Kinstle' exam, legendary for length and rigor, emphasized application of knowledge rather than rote learning," wrote former student Douglas Balogh in a letter nominating Kinstle for the university's 2004 Distinguished Teaching Professor Award.

"As many grumbling students discovered only later, having this experience was a significant advantage for them as [they] continued their education," added Balogh, now development projects manager at Eli Lilly and Company in Indianapolis, IN.

Kinstle helped bring former student Upali P. Weerasooriya (ACS '86) from Sri Lanka. When Weerasooriya couldn't pay for his airline ticket, Kinstle arranged a loan to pay for his passage. Weerasooriya attended Bowling Green in the mid-1970s. At that time, the university had only a master's degree program in chemistry. But Kinstle wanted his students to perform on par with Ph.D. candidates at major universities. When Weerasooriya joined the University of Texas at Austin for his doctoral studies, he took the qualifying

BOWLING GREEN STATE UNIVERSITY

TOM KINSTLE (ACS '58)

exams and performed so well that he was exempted from all core Ph.D. courses.

"As a teacher in the classroom, he was superb," wrote Weerasooriya, now vice president and chief technology officer at Harcros Chemicals Inc. in Kansas City, KS, in his nomination letter for the award. "I know from personal experience that he spent countless hours reading current chemistry literature in order to update his course materials."

Encouraging Undergraduate Research

Many great teachers are distinguished by their insistence on student excellence in research as well as classroom work. Claude Yoder (ACS '61), a chemistry professor at Franklin & Marshall College in Lancaster, PA, has published more than 120 papers, most with undergraduate coauthors. He believes that undergraduate research is the single most important part of many students' education.

Undergraduate research "provides an intellectual engagement with ideas, techniques, and methodology that serves students well no matter what career they pursue," Yoder said in an e-mail. "It also provides a genuine opportunity to be creative—to generate and then test new ideas or hypotheses—and to develop independence. Students learn that research involves much frustration, but the success that follows produces a great deal of self-satisfaction and increases their confidence."

Hilary J. Eppley (ACS '91) had Yoder for freshman chemistry in 1987. She started working with him that summer, first doing literature reviews and then moving into the lab. She remained in his lab during her entire undergraduate career, enjoying the camaraderie—and the practical jokes—in the summer research groups. The four papers she wrote with him helped her secure a National Science Foundation fellowship for graduate school.

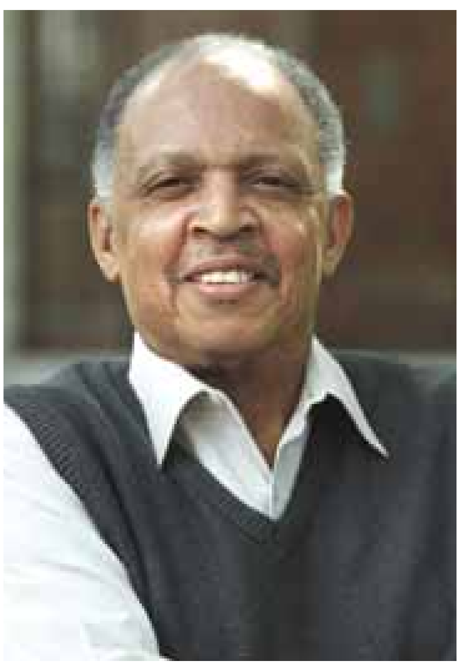
Eppley, now a chemistry professor at DePauw University in Indiana, directs undergraduates in research. "A lot of the reason I'm doing that is because of my interactions with Dr. Yoder," she said. "He constantly pushed his students to do better and work harder. Even now, he's like, 'You need to get that out and published,'" she said.

At The College of Wooster in Ohio, Ted Williams spent more than four decades pushing his students and encouraging them to experiment before his death in 2005. Williams received the ACS Division of Analytical Chemistry Award for Excellence in Education in 1989 and was chosen to receive the prestigious Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring in 2001.

"Williams' greatest skill, I think, was his ability to size up students and interact with them as persons and to give them a lot of freedom and encourage them to be creative," said former student J. Michael McBride, a chemistry professor at Yale University. If McBride came up with an idea he wanted to test in the lab, such as modifying an experiment described in a textbook, Williams encouraged him to try it, even though "it made it very difficult to teach because you had everybody doing different things instead of all doing the same things."

During his years as an emeritus professor, Williams offered this guidance to other teachers: "Have expectations for students, but don't be judgmental," he said. "I used to say to my colleagues, 'Be nice to all your students. You can't tell who's going to be famous.'"

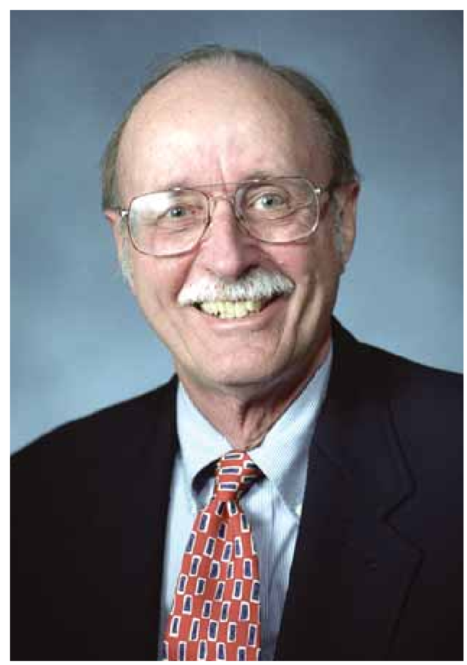
Rachel Smolkin writes on education and other topics for newspapers, magazines, and other publications. A regular contributor to Chemistry, *she authors our Student Affiliates column. Ms. Smolkin is based in Washington, DC.*


MATT DILYARD, THE COLLEGE OF WOOSTER

TED WILLIAMS


PEG SKORPINSKI

ANGELICA STACY


UNIVERSITY OF KANSAS

BOB CARLSON (ACS '59)

Among the Greats

George S. Hammond (died 2005)

Hammond taught for three decades at Iowa State College (now University), the California Institute of Technology, and the University of California at Santa Cruz. He is famous for his pioneering work in the field of organic photochemistry and his gift for attracting and training talented students.

Harry Gray (ACS '59)

Legendary for his pranks and his inspiring teaching, Gray began his career at Columbia University in 1961 and moved to the California Institute of Technology in 1966.

Henry C. McBay (d. 1995)

The Morehouse College professor inspired hundreds of African-American scientists. Forty-five of his Morehouse graduates later earned Ph.D.s in chemistry.

Donald Cram (d. 2001)

The Nobel laureate and National Medal of Science winner taught at the University of California, Los Angeles, for more than 50 years. He also coauthored a popular organic chemistry textbook with Hammond. Cram was famous at UCLA for playing his guitar and singing to his undergraduate students on the last day of class.

Thomas Kinstle (ACS '58)

Kinstle has challenged students at Bowling Green State University in Ohio for more than 30 years. "I've had fewer than 10 professors that I would rank as truly excellent teachers," one former student said. "Kinstle clearly is among the best of these few."

Emma Perry Carr (d. 1972)

A physical organic chemist at Mount Holyoke College in Massachusetts, Carr was known as an excellent teacher and researcher who gave her students pioneering opportunities to conduct research with professors.

Robert Carlson (ACS '59)

Carlson has taught at the University of Kansas in Lawrence for more than 40 years. He "has pushed his students to master the material not by mere memorization but by analyzing, questioning, and applying the concepts," noted one award citation.

Ted Williams (d. 2005)

Williams, an analytical chemist, taught at The College of Wooster in Ohio for more than 40 years. Former student Lee Eberhardt Limbird, associate vice chancellor for research at Vanderbilt University Medical Center, observed, "His nudging, which sometimes can be likened to a thumbtack on one's chair, doesn't stop at graduation."

Jeanne Pemberton (ACS '77)

The University of Arizona chemistry professor had little interest in teaching until she met her own first great chemistry teacher at the University of Delaware. "I really knew I found my niche," Pemberton said when she was honored by the National Science Foundation.

George Wald (d. 1997)

Time magazine hailed the Harvard University biochemist and Nobel laureate as one of the nation's best teachers. In lectures, "I am just trying to make things clear to myself—I find I am learning things all the time," he told the magazine.

Claude Yoder (ACS '61)

Yoder won the Franklin & Marshall College Lindback Award for Distinguished Teaching. The "rapport between student and faculty member is, in my experience, unmatched by any other educational experience," he said of collaborating with undergraduates on research.

Annis Hapkiewicz

For 30 years, Hapkiewicz has taught chemistry at Okemos High School in Michigan. The winner of the 2005 ACS James Bryant Conant Award in High School Chemistry Teaching, Hapkiewicz is also the K–12 science coordinator for Okemos and an adjunct instructor at Michigan State University.

George C. Pimentel (d. 1989)

The Berkeley professor is renowned for his work on CHEM Study, a national project to advance high-school chemistry teaching, and for his dedication to students. "Believe in yourself and fill your life with things to believe in," he advised at a commencement address just before his death. "Don't be afraid to try new things—to think new thoughts. Be bold. Be daring."

Ronald Magid (ACS '59)

Magid joined the University of Tennessee faculty in 1970. "He is both a unique and gifted teacher," said department head Craig Barnes (ACS '76). "I frequently receive notes from students who took his sophomore organic class just last semester—or thirty years ago—saying very simply that Dr. Magid was a teacher they will always remember for being such a positive influence in their lives while at UT."

Hubert Alyea (d. 1996)

After Walt Disney saw the famed Princeton University professor lecture, he used Alyea as a model for *The Absent-Minded Professor.* Nicknamed "Dr. Boom," Alyea taught for more than four decades, traveling the world to perform demos and lecture. His famous concluding lecture for students was known informally as "One Hundred Explosions in Fifty Minutes."

Angelica Stacy

This Berkeley professor was honored by the National Science Foundation as a 2005 Distinguished Teaching Scholar. Stacy developed a high school chemistry course and a new undergraduate class for non-science majors; she also started a course in which undergraduate and graduate students instruct elementary school pupils.

More Greats: ????

Chemistry's readers can fill in this list, which will be the topic of a future article and will help organizers of a symposium at the 2007 national meeting in Chicago. Just submit the name and a brief commentary on what made the individual an outstanding chemical educator to: chemistryteacher@acs.org

Burning Questions about Gas Hydrates

Methane hydrates are nothing less than ice that *burns.* In an era of growing concern about energy prices and shortages, gas hydrates offer the potential of a vast new source of natural gas. These odd gas traps also are playing a role in the debate over global warming.

BY BARBARA MAYNARD

A Canadian fishing crew hauled in an unusual catch off the coast of Vancouver Island several years ago. Instead of fish, they netted what looked like a 450-kilogram chunk of ice. Unlike ordinary ice, however, it began to hiss and steam. If a crew member had struck a match, the chunk would have burst into flame.

The ship had unwittingly discovered a large reserve of methane hydrate, a strange conglomeration of water ice and methane packed with hopes and fears in this era of growing concerns about energy supplies and energy's impact on the environment.

Methane hydrates, on one hand, could supply the world with a new source of clean energy that could last for decades. Methane (CH_4) is the main component of natural gas. Deep-ocean hydrate deposits also are a prime candidate for storing waste carbon dioxide from industrial smokestacks, rather than allowing it to enter the atmosphere. On the other hand, there are concerns that huge amounts of methane released from deep-sea deposits could shift global warming into high gear.

Regardless of their economic and environmental implications, gas hydrates are undoubtedly fascinating.

Methane hydrates look like ice—until you put a match to them. Then they burn, as some researchers love to demonstrate. Methane hydrates form at relatively low temperatures and high pressures—such as those found at 500 meters or more under the ocean, for example. Under these conditions, water forms a cage-like structure that is stabilized through Van der Waals forces by the insertion of a molecule of gas into the cage. Various small gases can be the guest molecule, but the most common naturally occurring gas hydrates contain methane. Methane hydrates are found under the sea floor along outer continental margins and in permafrost regions—locations that provide the high pressures,

relatively low temperature, and large amounts of methane required for their formation. The margins are vast, relatively shallow areas of ocean floor along the continents.

The hydrate structure packs a lot of gas into a small volume: "The gas hydrate at 1 atmosphere of pressure will contain about 160 times the volume of methane as methane gas at that same pressure," said William Dillon, researcher emeritus with the U.S. Geological Survey (USGS). In contrast, liquefied natural gas (LNG) has about 385 times the energy density of free gas.

Energy Resource Potential

Nobody knows exactly how much methane is frozen in hydrates, and the estimates range from about 1,000 gigatons of carbon in the form of methane to 22,000 gigatons. Most experts put the figure at about 10,000 gigatons. Earth's atmosphere contains about 700 gigatons of carbon. Put another way, the USGS estimates that the amount of natural gas in hydrate form is somewhere between 100,000 and 270,000,000 trillion cubic feet (tcf). That far exceeds remaining worldwide conventional natural gas resources, which are thought to total about 15,000 tcf.

In 2002, the United States used 27 tcf of natural gas and global consumption totaled 92 tcf, according to the U.S. Energy Information Administration. Needless to say, hydrates have generated worldwide excitement about their potential as an energy source.

The U.S. Congress enacted the Methane Hydrate Research and Development Act of 2000, which charged the Department of Energy (DOE) with coordinating a national, collaborative effort toward the eventual exploitation of methane hydrates. Congress renewed the act in 2005 as part of the Energy Policy Act, which also included a new provision for royalty relief. It includes subsidies for producing hydrates commercially by 2018. However, more work must be done in order to tap this resource.

International collaborations for hydrate research have formed among organizations and agencies from the United States, Japan, India, Germany, Canada, and other nations. Japan, for example, started a 16-year methane hydrate exploitation program in 2001. "Generally, everything is going well for the research program and we have learned much," said Takashi Uchida, a senior researcher with the Japan Petroleum Exploration Company. "Whether and when methane hydrate extraction will be economically viable should be considered in the next phase. Offshore production testing is planned early in Phase II, which will be the first offshore production test."

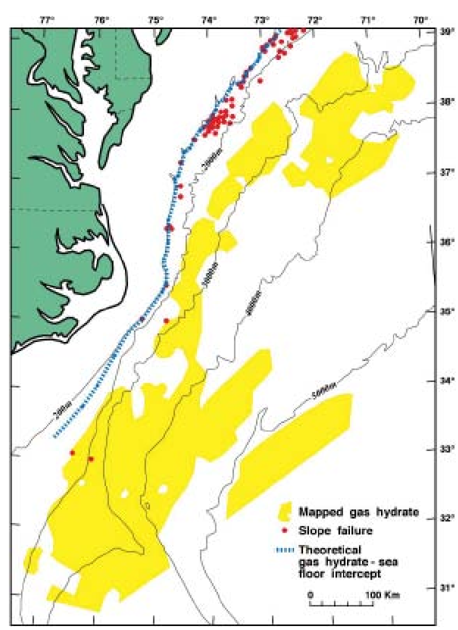
Locating Hydrates

Seismic data are the mainstay of current efforts to find potential hydrate fields. A pattern called a bottom-simulating reflector (BSR) in the seismic profile indicates the presence of hydrates—the dark band represents free gas trapped underneath an impermeable hydrate cap. The tool is not perfect, however. Hydrates have been found in the absence of a BSR.

A consortium of industry scientists sponsored by DOE has been developing a better method for detecting and characterizing gas hydrates in the Gulf of Mexico. During the spring of 2005, the team took to the sea to test their new technique. "The cruise is one step in a process of trying to improve our ability to predict and quantify, for a number of reasons, where hydrates are located in the sediment," said Emrys Jones, Research Consultant with Chevron-Texaco. The new method involves reanalyzing existing seismic data. Jones continued, "We would very much like to be able to do that with just conventional-type seismic information that is available, rather than have to spend a great deal of time and effort to locate the hydrates in another fashion."

USGS

HYDRATES IN HAND
Chunks of gas hydrate recovered from a core taken in the Gulf of Mexico.



WILLIAM DILLON, USGS

UPPER LIMITS
The theoretical upper limit of gas hydrate occurrence coincides with known seafloor failures.

The month-long research cruise aboard the semi-submersible vessel *Uncle John* collected ground-truth data by drilling cores and wells. "What we're trying to figure out now with this cruise is just how good a job we've done," Jones explained. "I would say that it's pretty clear that it's not perfect yet, but I don't know how far off from perfect it is. I think that we're going to end up with more modifications to our predictive techniques because we're not precisely getting what we predicted we'd get."

Other Variables Affect Hydrate Stability

While temperature and pressure curves are used to predict and describe regions of hydrate stability, other factors are also important. Carolyn Ruppel of the Georgia Institute of Technology argues that the spatial variability of salinity, temperature, and gas composition in the northern Gulf of Mexico deserve more attention in predicting hydrate reserves.

The Gulf of Mexico is rich with salt domes, old salt deposits buried deeply in sediments. "It's long been known that various salts, because of some ionic effects, inhibit the stability of gas hydrates," Ruppel said. "Once you start adding salt, you tend to make it more difficult to form gas hydrate or to keep it stable."

In addition to salt, heat might also play a bigger role in the northern Gulf of Mexico than previously considered. "Both of the sites we focused on in this paper are mud volcanoes. People don't know a lot about mud volcanoes, but it appears that there's probably a lot of fluid coming from significant depths, and these are hot fluids," Ruppel said. "The other thing is that the salt domes themselves actually contribute to raising temperatures in the sediments because salt has a very high thermal conductivity relative to the sediment. It seems that the northern Gulf has both things—both the temperature and salinity—working against it in terms of having a lot of gas hydrate in the sediments. It may be that the Gulf of Mexico is not the best target for looking for methane hydrates as a resource."

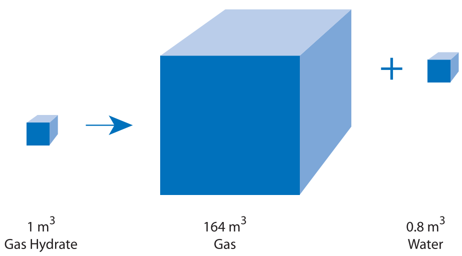
USGS

THE MALLIK DRILLING
Cores recovered from the Mallik drilling operation were quickly preserved in liquid nitrogen to preserve them for later analysis of gas content, porosity, thermal conductivity, and other characteristics.

TAKASHI UCHIDA, second from right, with research colleagues at the Mallik drill site in the Canadian arctic in 2002.

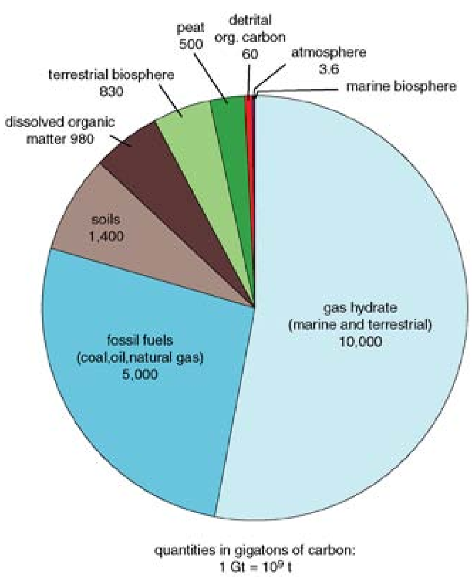
USGS

TEST PRODUCTION
Drilling equipment at the Mallik site in the Canadian arctic was used for the first production test of gas hydrates.



MARK MASLIN, UNIVERSITY COLLEGE LONDON

VOLUME MULTIPLIES
Methane hydrate dissociates into 164 times its original volume as free gas plus liquid water.



USGS/KVENVOLDEN

POSSIBLE ENERGY BONANZA
Estimates suggest that gas hydrates comprise over half of the world's organic carbon reserves.

Ruppel is quick to point out the indirect nature of the study. "We didn't actually quantify the amount of hydrate," she said. "We were simply saying that if you look at where the stability field would be for hydrate, it's going to be a lot thinner than people have previously claimed and, therefore, there is likely to be less hydrate in these particular types of areas."

How to Produce Hydrates

While more work remains to be done to pin down exactly how much methane exists in hydrate form, there is little doubt that the final number will be large. Whether or not that methane will be economically viable to produce, however, remains to be seen.

Natural gas may have already been produced from hydrates in two permafrost areas. The Messoyakha gas field in Siberia was a conventional gas operation that tapped a reservoir trapped beneath hydrate. As gas was removed, starting in 1969, the site did not show the expected and typical decrease in production volume. Scientists have proposed that the years of continued production were maintained by the dissociation of hydrates, which broke down as the gas beneath them was extracted.

The first deliberate test of natural gas hydrate production took place in 2002 in the Mackenzie Delta of the Canadian Arctic. One production and two observation wells were drilled to almost 1200 meters deep in the Mallik gas field. One of the highest concentrations of natural gas hydrates known worldwide, the Mallik field is buried beneath permafrost over 600 meters thick. The project demonstrated the technical feasibility of producing natural gas from hydrates.

A Hazardous History

Hydrates first attracted attention in the 1930s, when natural gas pipelines started to clog in low temperatures, creating dangerous conditions and interrupting the flow of gas. Once researchers identified gas hydrates as the problem, they developed several strategies to deal with them. Insulating pipes from cold, heating them, or removing water from them can prevent hydrate formation, but these methods are not always feasible. Hydrate formation remains a major problem today. In the United States, for instance, the natural gas delivery system consists of 2.2 million miles of pipeline. If hydrate formation cuts off the flow, customers large and small that depend on natural gas face the consequences.

Adding either methanol or glycols inhibits hydrate formation, apparently by bonding to the hydroxyl group of the water molecules. However, this approach presents toxicity issues for the operator. Less toxic, low-dosage inhibitors are slowly gaining acceptance in the industry, according to Lynn Frostman (ACS '92) of Baker Petrolite. The compounds incorporate themselves into the hydrate structure and prevent the growth of larger crystals. This allows hydrates to form, but prevents them from aggregating into large pieces that cause problems.

As conventional operations have pushed to drill deeper beneath the ocean floor in recent years, hydrates have presented new

NATIONAL ENERGY TECHNOLOGY LABORATORY

RESEARCH WITH *UNCLE JOHN*
The semi-submersible vessel *Uncle John* was used on a Spring 2005 research cruise to study gas hydrates in the Gulf of Mexico.

safety challenges. "When we are going after deeper hydrocarbons, we sometimes run across an area that has hydrates in it," Jones said. "The concern is how they will affect the sediments that we drill through, and how they will affect the sediments that we put production-type equipment on."

Drilling through hydrates can release the pressure or raise the temperature as hot fluids are piped up from underneath the hydrate layer. Either effect can rapidly dissociate hydrates, leading to gas blowouts, highly pressurized pockets of gas, or the collapse of sediments that support the drilling equipment.

"The hazards to industry infrastructure could potentially be substantial," Ruppel said. "For example, theoretically we're pumping hot fluids from a conventional oil reserve up through the hydrate stability zone. We could destabilize hydrates in the hydrate stability zone, and that part of the seafloor is what is holding up our platform."

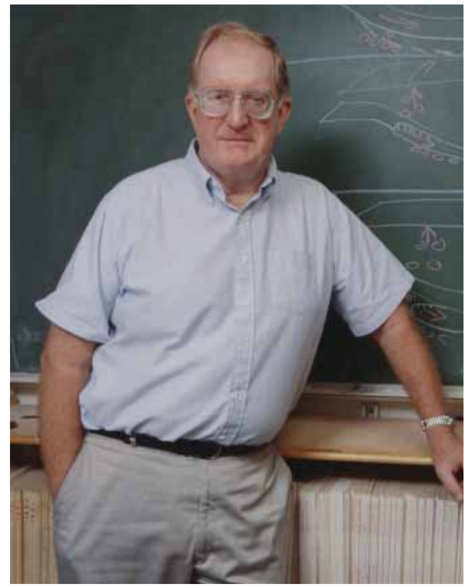
Cores and drilling logs gathered on the 2005 *Uncle John* cruise will help engineers address these stability and safety issues. "We were trying to collect information on hydrate-bearing sediments that would tell us what their mechanical transport and acoustic-type properties are, for various reasons," Jones said. "Those things are used for the modeling of the well bore stability to know that when we are drilling a hole, it doesn't slough off or fall in on us."

While industry is learning more about how to model the behavior of hydrates, researchers are also refining means to prevent hydrate dissociation. "What you want to do when you're drilling is avoid melting the gas hydrate," Dillon said. "You can do that by insulating the pipe, by chilling the drilling fluid, by using inhibitors that make the gas hydrate more stable. There are drilling techniques that can be used to make drilling in gas hydrates safer."

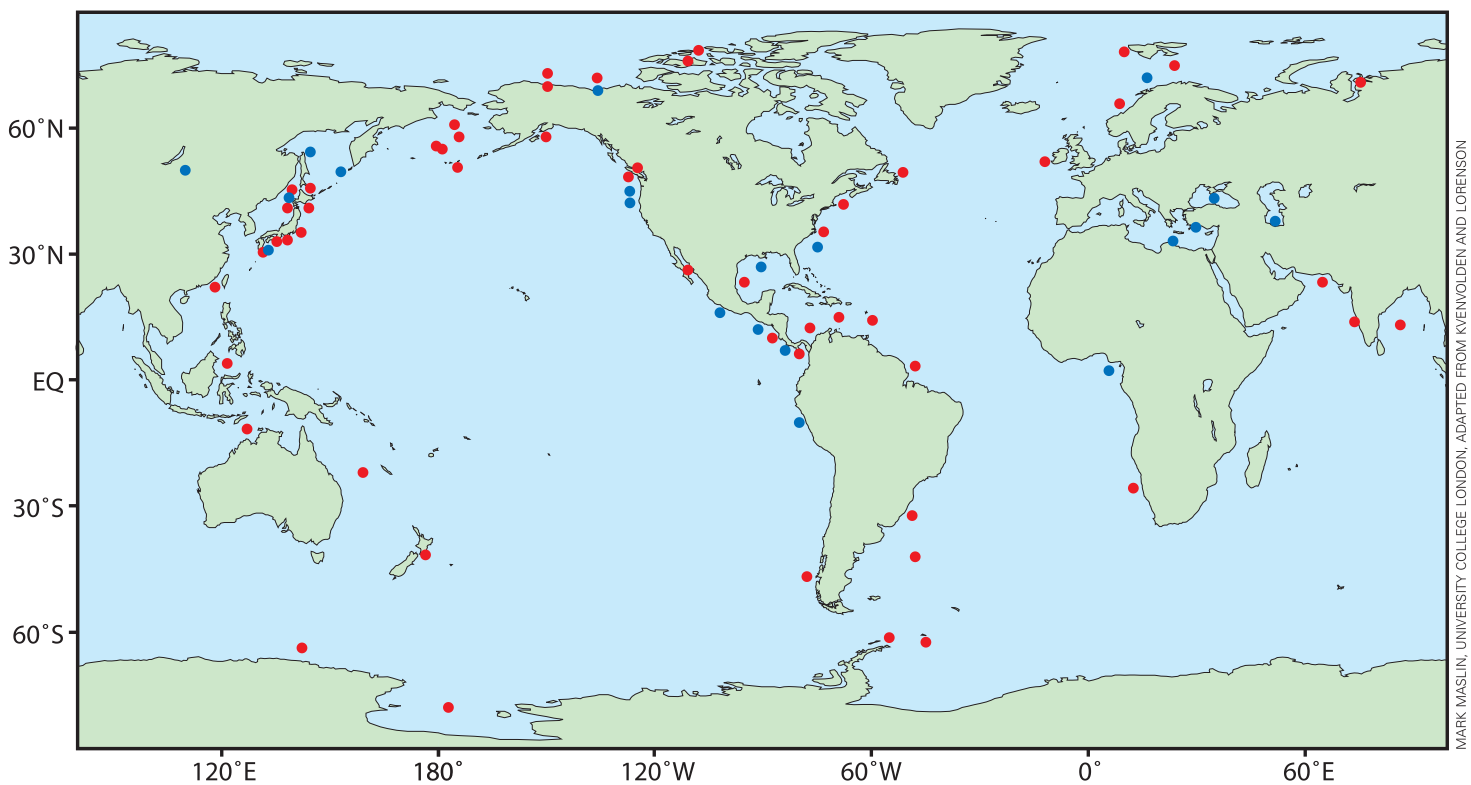
Hydrates and Global Warming

Using natural gas for energy has environmental benefits. Burning pure methane produces carbon dioxide and water, and the high hydrogen-to-carbon ratio means less carbon dioxide is produced than from other fossil fuels. Therefore, natural gas is considered a relatively clean energy source. Hydrates, however, do have environmental drawbacks.

Because methane absorbs different wavelengths of energy than does carbon dioxide, it is 21 times more powerful as a greenhouse gas. Given hydrates' dependence on cold temperatures, this means not only that global warming can dissociate hydrates, but also that the subsequent release of methane can then exacerbate



WILLIAM DILLON



GLOBAL HYDRATE RESERVES

Red dots indicate locations where hydrate has been inferred from a BSR or other data. Blue dots indicate locations where gas hydrates have been recovered.

global warming, leading to a positive feedback loop—with negative consequences.

"The major recent finding from models of future climate change is that warming of the ocean 2–3 °C will cause gas hydrate to break down in the ocean sediments and this will release methane into the ocean and atmosphere," said Mark Maslin of the Environmental Change Research Centre at University College London.

"What we learn from the past is that gas hydrates can be released either by rapid drops in sea level of tens of meters or temperature rises of 2–5 °C. We are entering a climate change period when ocean temperature outweighs sea level and thus gas hydrate release will occur. The only thing we can hope for is that it occurs slowly and this released methane oxidizes in the water column and thus stays in the ocean. If these releases are explosive, then the methane will be able to come straight into the atmosphere and accelerate global warming."

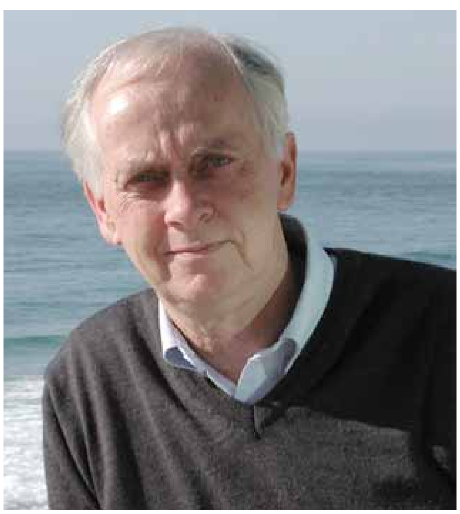
Maslin suggests that hydrates found below permafrost may be especially important in the coming decades for two reasons. First, high latitude temperatures are expected to rise in the next one hundred years by up to 8 °C and second, rising sea levels will flood areas of permafrost with water at -1 °C. "Compared with -20 to -40 °C permafrost, this is a huge thermal shock, which will release any gas hydrate trapped there," Maslin said.

Methane hydrates have been implicated in past climate change and accompanying species extinctions. "I think they have played a major role in abrupt and massive climate changes like those at the K/T boundary (Cretaceous–Tertiary boundary, 65 million years ago) and also the PETM (Paleocene–Eocene thermal maximum, 55 million years ago)," Maslin wrote. The K/T boundary marks the transition from the dominance of dinosaurs to that of mammals, and the PETM corresponds to the rise of terrestrial animals, including primates, and the fall of many deep ocean species.

Some scientists have thought that methane hydrates could mediate climate change if a rise in sea level caused by melting ice caps increased pressure enough to enlarge the hydrate stability zone. However, recent calculations predict that this will not happen with the current global warming pattern. "The sea level increase predicted for the next 100 years is too small (20–80 centimeters) to have any stabilizing effect on the gas hydrate reserves," Maslin wrote.

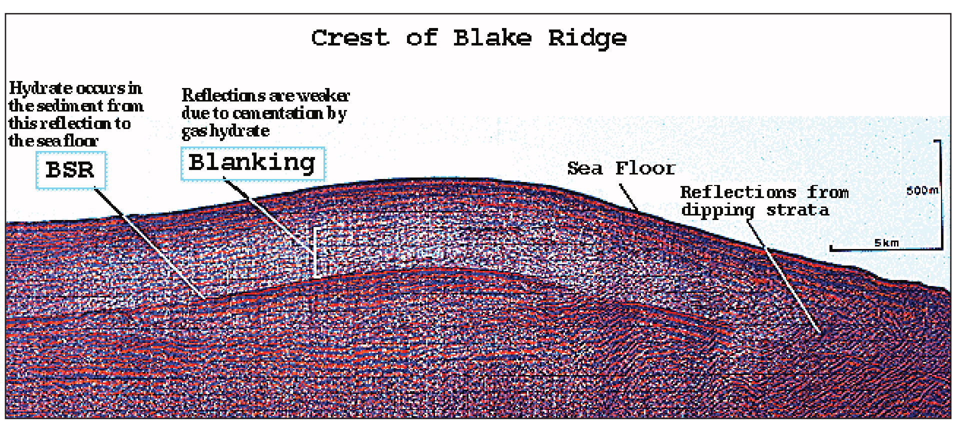
Dissociation of hydrates can also lead to undersea landslides as the solid "ice" that had cemented the sediment together disintegrates into liquid water and gas. Dillon made the connection between hydrates and landslides in work he did with Jim Booth of the USGS. "I had been mapping gas hydrates on the east coast of the United States," Dillon said. "We looked at the map of the gas hydrates and superimposed that on a map of the landslides off the east coast of the United States." The tops of the

MARK MASLIN



TODD WALSH © 2004 MBARI

PETER BREWER (ACS '79)



USGS

SOUTH CAROLINA HYDRATE FORMATION

A seismic profile taken from the Blake Ridge, off the coast of South Carolina, indicated the presence of hydrates. The BSR indicates free gas trapped beneath solid hydrates. The lighter region, referred to as blanking, indicates the presence of hydrate in the sediment.

RAM SIVARAMAN

major landslides all occurred near the gas hydrate limit.

Hydrate-triggered landslides, in conjunction with the consequent release of more gas from beneath the hydrate, can in turn cause tsunamis. "We would expect these gas hydrate–caused failures to produce tsunamis in areas that normally do not experience them, for example, the North Atlantic," Maslin wrote. "The Norwegian Storegga slide of 8,000 years ago caused a 15-meter high tsunami (about the same height as the 2004 Boxing Day tsunami in southeast Asia)."

New Applications: Sequestering Carbon Dioxide and Storing Methane

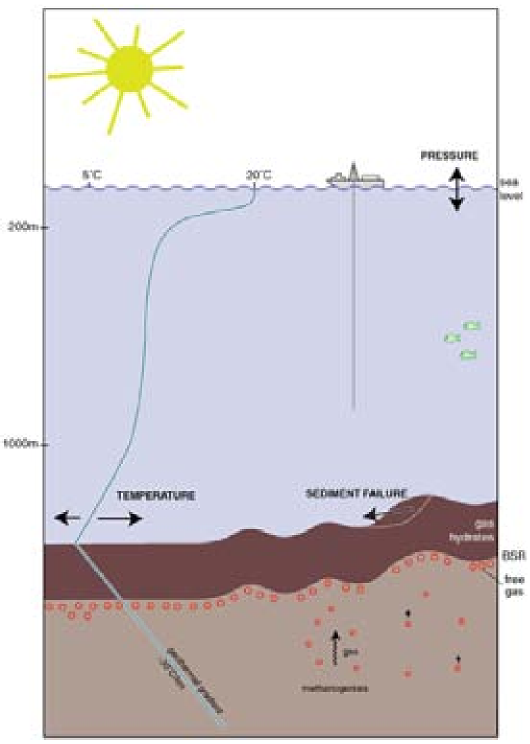
Ram Sivaraman, principal scientist at the Gas Technology Institute (GTI), believes hydrates can be a source of energy while simultaneously reducing global warming. He is developing a strategy to sequester carbon dioxide and produce methane in the same process.

"When I did some calculations, the heat of formation for hydrates of carbon dioxide is close enough to the heat of dissociation for methane hydrates," he said. Therefore, it is thermodynamically possible to replace methane with carbon dioxide in deep-sea hydrate sediments. Sivaraman has successfully tested his idea in a high-pressure chamber at GTI. Under conditions that mimic those in the Gulf of Mexico, he injected carbon dioxide into methane hydrate–containing sediment. "The calculations indicated that the hydrate didn't dissociate, but still we are getting methane," he said. "There is only one way it can happen—if carbon dioxide is going in and displacing methane in the sediments." He said this process has two benefits: "No matter how much methane you get, still carbon dioxide has been sequestered."

Sivaraman is also working on a project to store natural gas in hydrate form. Promoters—the opposite of the chemical inhibitors used to prevent hydrate formation in pipelines—facilitate the formation of methane hydrates at room temperature, provided there is sufficient pressure. Development of this approach would enable storage of large reserves of natural gas efficiently, which he suggests will be a cost-effective way for large cities to weather periods of high demand and short supply of natural gas. ⬢

Barbara Maynard, Ph.D., is a freelance science writer in Alaska, where she is getting firsthand exposure to both changing climate and growing excitement over the energy potential of methane hydrates.

MARK MASLIN, UNIVERSITY COLLEGE LONDON



HYDRATES AND HYDRATE STABILITY ZONE
Gas hydrates are stable under high pressures and low temperatures, like those found 500 meters or more beneath the ocean surface. Farther beneath the seafloor, temperatures start to rise, forming the lower limit of the hydrate stability zone. The bottom-simulating reflector (BSR) indicates free gas trapped beneath solid hydrates.

Unique Substance Breeds Unique Species

While people strategize how or whether to tap methane hydrates as a resource, another animal already has moved in.

In 1997 Charles Fisher, a biology professor at the Pennsylvania State University, was sampling deep ocean species in the Gulf of Mexico when his crew decided to investigate a nearby hydrate mound. "Hydrates were not the purpose of that cruise," Fisher said. "We were out there studying tubeworms."

As the team approached the hydrate, Fisher recounted, they saw something moving: pinkish worms, 3–5 centimeters long, now known as *Hesiocaeca methanicola*. "We knew on the seafloor when we saw it that it was unique, that nobody had ever seen it before, that it was a new species, that it was a whole new kind of ecosystem."

Fisher believes that the worms graze on chemosynthetic bacteria that use hydrogen sulfide to grow on hydrates. "The bacteria that the worms are eating seem to be using sulfide for energy. We fully expected it would be methane, but we did stable isotope analyses," he said. "It turns out that sulfide is a hydrate gas as well and that many of the hydrates in the Gulf of Mexico, including this one, have appreciable sulfide in them."

—BM

CHARLES FISHER (ACS '94), PENN STATE UNIVERSITY

HYDRATE INHABITANTS
Pink "iceworms" inhabit exposed hydrates in the Gulf of Mexico. The worms graze on the chemosynthetic bacteria that grow on hydrates and use sulfide for energy.

Lindau: A Nobel Conference

An unusual conference on Lake Constance in the Swiss Alps gives students a once-in-a-lifetime opportunity to interact casually with Nobel laureates. Students return home with new insights into everything from scientific discovery to the meaning of life.

By John K. Borchardt

Imagine spending a week in the picturesque island city of Lindau in Germany, near the border of Austria and Switzerland. You enjoy the natural beauty of Lake Constance, the Alps, and a medieval city that showcases central European culture. Your companions for leisurely strolls, meals, and informal one-on-one chats are Nobel laureates. The topics open for discussion: just about anything—the process of scientific discovery, the keys to a successful career, maybe even the meaning of life.

Over the years, thousands of young scientists in chemistry, physics, and medicine have had that once-in-a-lifetime opportunity thanks to a unique conference that gets precious little public attention.

"To have a conversation with a winner of a Nobel Prize in science is not a humbling experience but an invigorating and motivating one," said Bryan Kaehr, a chemistry graduate student at the University of Texas at Austin.

This is the experience Kaehr and approximately 700 other graduate school students and postdocs—in chemistry, physics and medicine—came from around the world to share, like thousands of others over the years, at the 55th Meeting of the Nobel Laureates in Lindau, Germany, June 26–July 1, 2005.

"It provides opportunities for early-career scientists to interact intensively with both Nobel laureates and students from other countries," said Roland Hirsch (ACS '65), of the U.S. Department of Energy (DOE) and one of the coordinators of U.S. student participation in the conference. Known as the Lindau Conference, it provides opportunities for young scientists to hear Nobel laureates describe their research, other aspects of their careers, and their views on major science-related questions such as global warming. In addition, the students meet informally with Nobel laureates at meals and social events.

Count Bernadotte's Patronage

Of course, without Alfred Nobel's legacy there would be no Nobel Prizes and no Nobel laureates. However, the Lindau Conference began to emerge in 1951, when two local physicians got the idea of holding a conference to encourage international scientific exchange among outstanding young scientists and Nobel laureates. Gustav Parade and Franz Karl Hein approached Count Lennart Bernadotte of Wisborg, from the nearby island of Mainau. He became an advocate and patron. The Count's family already had a long association with the Nobel Prizes. His great-grandfather was Swedish King Oscar II, who presented the very first Nobel Prizes. Although Bernadotte died recently and the countess is in poor health, she and their three children want to continue the family tradition of acting as patrons of the conference.

The first Lindau Conference, held in 1951, was for medical specialists. Later the conference expanded to include chemistry and physics. Since 1970, Nobel Prize winners in economics have occasionally attended separate conferences.

Certain themes that originated in the first meeting continue today. The emphasis remains on a relaxed atmosphere that encourages informal discussions in addition to lectures and panel discussions. The conferences have promoted international cooperation in scientific research, a cooperation facilitated today by e-mail. Topics range from details of scientific research to its consequences and social implications. By example, the Nobel laureates provide inspiration and instill the determination to persevere in graduate students attending the conference.

Approximately 500–700 top students attend each Lindau Conference. Initially, all the participants came from Germany, but now some 45% of them travel from countries all over the world, making it an international event. Donors and sponsors facilitate international participation by paying partly or in full for travel, accommodations, and the conference fee. The Council for Lindau Nobel Laureate Meetings has developed criteria which, along with recommendations from mentors, provide a basis for choosing students to attend the conference.

Three organizations in the United States provided funding for students and arranged for them to attend the 2005 Lindau Conference. They were the National Science Foundation, the DOE, and Oak Ridge Associated Universities.

Both Nobel Prize winners and students praised the 2005 conference. "The students, U.S. and international, were a very inquisitive group overall," said Sherwood Rowland, a 1995 chemistry laureate from the University of California, Irvine. Chemistry graduate student Kirsten Griffiths (ACS '03) of the University of California, Los Angeles, commented, "The Lindau experience was amazing, and I encourage all eligible graduate students to apply." (For application information for the 2006 Lindau Conference, check the sidebar on page 36.)

Preparing for Lindau

The 2005 Lindau experience began two days before the conference when U.S. students met on June 24 in Washington, DC, for orientation. This provided a chance for the students to get acquainted and to learn about the three U.S. conference sponsors and their missions. Hirsch, who is with DOE's Medical Science Division, presented an overview of the history of the Nobel Prizes, Germany, German culture, and the Lindau area. Orientation participants discussed the conference schedule. Linda Holmes, who manages the Lindau attendee selection process at the Oak Ridge Associated Universities (ORAU), provided

SAM HELD, OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

ALAN MacDIARMID (ACS '55) makes noteworthy observations to a student before his lecture, "The World Is Becoming Smaller."

SAM HELD, OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

ELIZABETH JOHNSON, left, shared dinnertime conversation with JOHN FENN (ACS '41).

Applying for Lindau 2006

Now is the time to start, if you hope to attend the 2006 Lindau Conference. It is scheduled for June 25–30 and will be the eighteenth to focus on chemistry. As in the past, the typical Lindau Conference attendee will be a second- or third-year chemistry graduate student who has already picked a thesis adviser. The list of universities providing participants indicates that U.S. chemistry attendees come from a large number of universities, not just an elite few.

Who is eligible to attend Lindau? DOE's Roland Hirsch (ACS '65) explains that students whose thesis advisers receive research funding from the National Science Foundation Mathematics and Physical Sciences Directorate or the Department of Energy may apply. Graduate students at the 90 universities that belong to the Oak Ridge Associated Universities (ORAU) may also apply. The ORAU Trust for Science Education sponsors 10 students per year for the Lindau Conference, with the NSF and DOE each sending 25 students annually. These organizations pay the students' total expenses, approximately $4,000 each, for attending the event. The ORAU Trust, NSF, and DOE each have a coordinator who manages the process of selecting graduate students.

The application forms for the Lindau Conference run approximately five pages. They include a recommendation from the applicant's thesis adviser and a short essay explaining why the student feels that he or she would like to attend the Lindau Conference. They are available at www.orau.gov/lindau2006.

According to Linda Holmes, who manages ORAU's Lindau selection process, the sponsors try to select the people who will be future scientific leaders. She comments, "These students are the cream of the crop."

Ms. Holmes manages all communications with the students and arranges meeting logistics such as hotels, travel arrangements, and meals. She also organizes social events with the Nobel laureates for all the U.S. students.

—JKB

advice about how to get the most out of the conference. "By meeting the sponsors' representatives, the students may even be meeting possible future employers," she noted.

After lunch, the students flew to Munich, Germany, on two commercial flights that landed almost at the same time. The long-haul flights provided additional opportunities for students to become acquainted. Upon their arrival in Munich on June 25, the students spent the afternoon visiting museums in the historical heart of the city. After spending the night in Munich, they boarded buses for the two-hour trip to the island city of Lindau.

As soon as the U.S. delegation arrived, they checked into the Hotel-Garni Brugger and Hotel Move, then picked up their registration materials at the Inselhalle conference hall. The Opening Ceremony for the 55th Meeting of Nobel Laureates and Graduate Students took place there on Sunday, June 26. Count Bjorn Bernadotte presided over the ceremony.

Multidisciplinary Focus

Each Lindau Conference is usually devoted to a single scientific discipline. The last chemistry conference took place in 2002. In 2000 the 50th anniversary of the Lindau Conference celebrated with a multidisciplinary meeting. Nobel laureates in chemistry, physics, and medicine attended and presented lectures related to their fields. This year's gathering also addressed multidisciplinary topics. The 2006 meeting will again focus on chemistry.

"One of the nice things about the Lindau Meeting was its interdisciplinary nature," said Christa Chrovian of Wayne State University. "Even though the topic was barely ever in my direct field of interest, many of the Nobel laureates spoke in a very broad and incredibly motivational manner to the students." Yale University's Lori Burns agreed. "Most interesting to me was Professor David Gross's lecture on the future of physics," said Burns. "Through his presentation of unanswered questions in research, he relayed the vigor and beauty in investigating fundamental issues in science."

Socializing Before the Polonaise

The enjoyment extended to the informal discussions as well. "I believe that in my conversations with a number of Nobel laureates, I gained a deeper appreciation for all fields of science, which were represented quite well by the biology, chemistry, and physics winners, and not just my own tiny area of physical chemistry," said Damon Carl, of the University of Utah.

SAM HELD, OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

STUDENTS ENJOY INSIGHTS FROM PETER AGRE after the Nobel laureate lectured at the conference.

Robert Curl (ACS '68), 1996 chemistry Nobel laureate from Rice University, noted that the shorter twenty-minute talks were something new since he attended his first conference several years ago. Both Curl and 2002 chemistry Nobel Laureate John Fenn (ACS '41), of Virginia Commonwealth University, thought the short format was valuable because it enabled more laureates to make presentations to the students. "Students were keen to participate with questions and comments," said Curl, noting that these sessions "were a lot of fun."

Every evening included social functions and dinners enabling the graduate students to mix informally with the Nobel laureates. They began the first evening of the conference, when students and young researchers met at their tables. Each was assigned to one laureate for talking, dining, and eventually the Polonaise, that stately Polish processional dance, led by the President of the Committee. Then the event evolved into a dancing party. On the last day of the conference, all the participants enjoyed a boat excursion across Lake Constance to the Isle of Mainau, the home of the Bernadotte family. After visits to the Island Park in the morning, the President of the Committee, Countess Sonja Bernadotte, officially closed the conference at noon in the courtyard of Mainau Castle. Then the boat returned the conferees to Lindau in the afternoon.

The Lectures

Nobel Prize winners in chemistry presented many of the lectures this year. Aaron Chiechanover, 2004 chemistry Nobel Prize winner from the Technion in Israel, presented the first chemistry lecture of the conference, "Why Proteins Die, So We Shall Live," on Monday morning. Later that morning Kurt Wüthrich of the Swiss Federal Institute of Technology (2002 chemistry) spoke on the topic, "From Genome to Proteome—Impact on Biological and Biomedical Research."

Among the Nobel laureates discussing "Evolution of Matter, Universe, and Life" were Manfred Eigen (1967 chemistry), of the Max-Planck-Institut für Physikalische Chemie; Fenn; and Rudolph Marcus (1992 chemistry; ACS '50), of the California Institute of Technology.

That afternoon, Sir Aaron Klug (1982 chemistry) discussed "From the Laboratory to the Clinic: Towards Therapeutic Applications of Engineered Zinc Finger Protein." Alan MacDiarmid (2000 chemistry) of the University of Pennsylvania presented "The World is Becoming Smaller."

And so it went, with presentations by other laureates including Robert Huber (1988 chemistry) of the Planck-Institut für Biochemie; Kary Mullis (1993 chemistry), currently with the Children's Hospital and Research Institute in Oakland, CA; Richard Ernst (1991 chemistry) of the Eidgenössische Technische Hochschule Zürich; Yuan Tseh Lee (1986 chemistry), now president of Academia Sinica in Taipei, Taiwan; William Lipscomb (1976 chemistry; ACS '39) of Harvard University; Peter Agre (2003 chemistry) of the Johns Hopkins University School of Medicine; Roderick MacKinnon (2003 chemistry; ACS '02) of Rockefeller University; Walter Kohn (1998 chemistry) of the University of California, Santa Barbara; and Alan Heeger (2000 chemistry; ACS '84) of the University of California, Santa Barbara.

One roundtable discussion focused on the hot topic, "Energy Shortfall and Global Warming." Among the participants were Nobel chemistry laureates Sir Harold Kroto (1996), now with Florida State University; Paul Crutzen (1995) of the Max-Planck-Institute for Chemistry; Rowland; and Fenn.

SAM HELD, OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

CHARLES TOWNES CHATS WITH ELIZABETH JOHNSON AND LOUIS JISONNA JR.

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SIR HAROLD KROTO with students on a Lake Constance cruise.

Rowland was among the laureates who linked scientific research with societal concerns in their presentations. "My emphasis is on changes in the atmosphere, particularly ozone depletion, smog, and global warming," he said. "Besides speaking scientifically, I also discussed the interactions of these effects with lay society."

The Students

American chemistry graduate students were uniformly enthusiastic about their Lindau experiences. "Meeting many of the world's top scientists is a once-in-a-lifetime opportunity," said Germarie Sanchez-Pomales of the University of Puerto Rico. "The meeting was a scientifically, socially, and culturally enlightening experience." Steven Straight (ACS '03), of Arizona State University, termed it "the most inspiring experience I've ever had."

SAM HELD, OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

RODERICK MacKINNON (ACS '01)

For Christa Chrovian, the value wasn't in specific information the Nobel laureates provided, but in their "incredibly motivational manner to the students." Damon Carl was particularly inspired by Kroto's lecture, "2010—A Nanospace Odyssey." Carl noted, "His excitement for all science just lifts you up, gets you thinking about a number of issues." Chrovian agreed. "Professor Kroto's lecture made me so excited to be in the field that I am in."

Chrovian also was deeply impressed by the other laureates. "Their attitudes towards us as students and science in general was so refreshingly positive, they have encouraged me to keep a more open mind about what I am doing and to really try to think about how to take my project one step further." Elizabeth Johnson of the University of Iowa commented, "I enjoyed hearing their hopes for and faith in the students as the future of science."

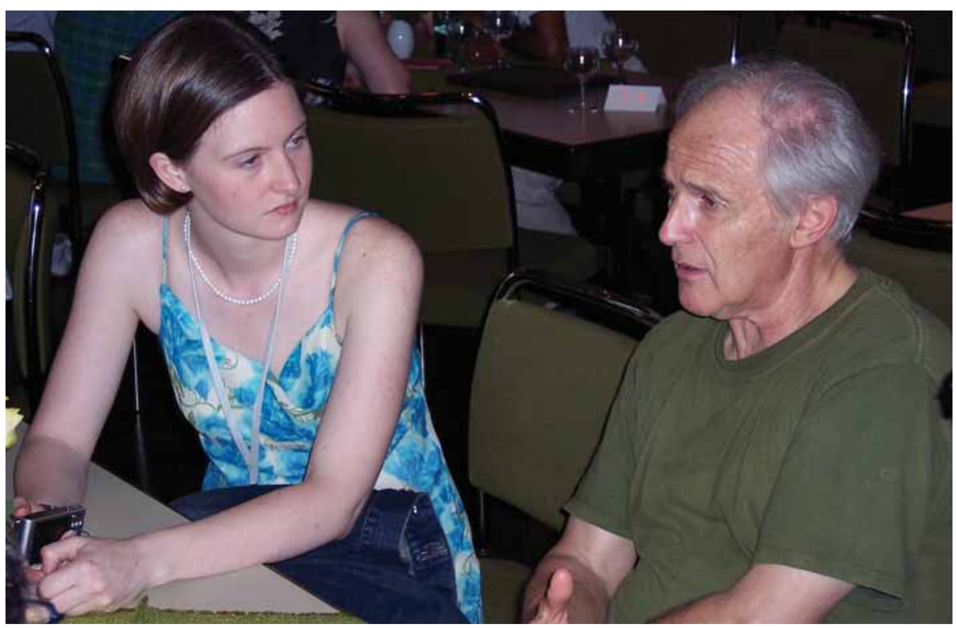
Many of the discussions the students had with the Nobel laureates went beyond chemistry itself to broader science-related topics. "I enjoyed my lunch with Peter Agre because we talked about social topics instead of just science," Northwestern University's Steve Bull said. "We discussed the educational system in the United States at the university level and where it was going wrong."

Discussions among the students also went beyond chemistry. "I found meeting other students of science from the United States and abroad to be a valuable experience," said Lori Burns. "Apart from the standard discussions of research, I particularly enjoyed comparing methods of scientific education throughout the U.S. and Europe."

Conference Rewards

John Fenn suggested that a lot of the value of the Lindau experience lies in the discussions among the students. "Plato had it right," he said. "Knowledge is by dialogue." And the students themselves engaged in plenty of that. "It was a fantastic opportunity to meet other students in a very social setting as well as talk with the brightest of the bunch," Steve Bull noted. Elizabeth Johnson added, "Getting to know the other students from around the world was a great experience." Lori Burns stated that she "found the Lindau Conference to be highly refreshing in that I met students who care intensely about their research and its prospects."

Christa Chrovian found the interactions with fellow students and the laureates rewarding for another reason. "The experience of acquiring ideas of how fellow



SAM HELD, OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

KIRSTEN GRIFFITHS (ACS '03) said informal discussions with Nobel laureates like SIR HAROLD KROTO made the Lindau experience "amazing," and she encourages other students to apply for a spot at the 2006 conference.

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SHERWOOD ROWLAND takes his hat off to students for being "a very inquisitive group" and enjoys Lake Constance's beautiful weather.

scientists think, what they think about, what they know, and what they feel is important, is invaluable," she pointed out. The students' thesis advisers may also be pleased with their attendance. "I came back to my work fresh and ready to study hard," said Damon Carl.

Oak Ridge's Holmes noted that the students learn about networking, a useful tool in later enhancing their research.

What gratifies the sponsors who attend the Washington orientation and the conference itself? "It is most rewarding to watch the students interact with other students and the Nobel laureates," Holmes said. "I enjoy seeing the twofold wonder of the students as they see their heroes and then quickly discover that the laureates are people too. They learn that the laureates have opinions—not always popular ones—and likes and dislikes."

The Nobel Laureates' Experiences

The meeting also proved to be a rewarding experience for the Nobel laureates. "I learned more from the students than they learned from me," Fenn said. "Old folks are like vampires—we live off the energy of the young." Attending his first Lindau Conference, Fenn also enjoyed and valued the discussions he had with other Nobel laureates, some of whom were friends he hadn't seen for a long time. Like Fenn, Curl found his conversations with both the students and the other Nobel laureates very pleasant and worthwhile.

What motivated the Nobel laureates to attend Lindau? Fenn explained that he wasn't there to communicate any particular message. "I was not on a mission," he said. "I was there to answer students' questions." Curl said the opportunity to interact with the students primarily interested him. "Unlike most graduate students, the Lindau students as a whole were a lot more active beyond just their research project," he observed. "They are really excited about science in general."

Some laureates helped instill this broader perspective in the Lindau students. Lori Burns cited "the broad span of fields represented by the laureates" and often embodied in a single individual. "It recalled to me the intense interest I once had in all of science." Burns added that as a result, in the future she would be "more mindful of situating [her] research" in the context of "a larger view."

The Nobel laureates also valued interacting with each other. "I am interested in what other Nobelists are talking about," Rowland said. Fenn echoed that sentiment: "People are social animals and Lindau is a social occasion."

Will the Lindau Conference help launch the careers of future Nobel Prize winners? Only time will tell. ⬢

John K. Borchardt (ACS '68), Ph.D., is an organic chemist and freelance writer based in Houston, TX. In addition to his articles in the popular media, John is the author of more than 100 technical papers and has been awarded 29 U.S. patents.

CROSSWORD solution

TO WINTER 2006 *CHEMISTRY* PUZZLE.

BY RANDY WEDIN

Sustainability and Green Chemistry—Not Just Buzzwords

"Green chemistry" and "sustainability" are not just sound bites, but a new paradigm that promises to have a deep and lasting impact on the science of chemistry.

Buzzwords, trends, fads…They strut proudly onto the stage of business, fashion, and politics—even the chemical industry. And then they fade just as quickly.

Sometimes, however, a new idea takes the stage and captures our imaginations, transforming everything and everyone. Across the chemical enterprise, we've reached just such a pivotal moment with the twin concepts of sustainability and green chemistry.

Here are three indicators heralding the arrival of this new paradigm:

- Green chemistry has emerged as a core theme at recent ACS National Meetings. In 2005 alone, 10 technical divisions sponsored a total of 19 symposia on the topic.
- The Dow Jones Sustainability Index (DJSI) was released in September. This is the first time Dow Jones has ever devoted a report exclusively to the sustainability of companies based in the United States. DuPont, 3M, and Pfizer rank among U.S. companies receiving high marks as leaders in corporate sustainability. Other chemistry-related companies on the list (www.sustainability-index.com) include Air Products, Praxair, Abbott, Bristol-Myers Squibb, Genzyme, Kodak, and Procter & Gamble.
- The National Research Council of the National Academies, through its Board on Chemical Sciences and Technology, recently published a report titled *Sustainability in the Chemical Industry: Grand Challenges and Research Needs* (http://dels.nas.edu/bcst/reports.shtml).

The new paradigm of sustainability and green chemistry has clearly arrived. But what exactly are these concepts? And how will they change the way industrial chemists do their jobs?

Defining Sustainability and Green Chemistry

The concept of sustainability first gained attention in 1987, when the United Nations' World Commission on Environment and Development published *Our Common Future,* defining sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." Another definition calls it the "triple bottom line of twenty-first century business," with three concurrent goals—economic prosperity, environmental quality, and social justice.

The goal of sustainability involves all sectors of our economy—from agriculture to computers, from housing to transportation, from energy to pharmaceuticals. When tackling the individual challenges in each of these sectors, said Paul Anastas (ACS '95), director of the American Chemical Society's Green Chemistry Institute (GCI), "We'll need to drill down to the molecular level, where you can have the most influence."

That's where green chemistry enters the picture. "Green chemistry is one of the most fundamental and powerful tools to use on the path to sustainability. In fact, without green chemistry and green engineering, I don't know of a path to sustainability," Anastas said.

Green chemistry rests on 12 principles, such as safer solvents, design for energy efficiency, and use of renewable feedstocks. A closely related field, green engineering, has its own set of 9 principles, such as using life-cycle thinking and minimizing depletion of natural resources. More detailed descriptions of these principles can be found on the GCI and EPA websites

(chemistry.org/greenchemistryinstitute and www.epa.gov/opptintr/greenengineering).

Together, the principles of green chemistry and green engineering are bringing change to all segments of the chemical industry. One of the sectors seeing especially big changes is the pharmaceutical industry.

Green Chemistry in the Pharmaceutical Industry

Until recently, the most important metric for managing process development in the pharmaceutical industry was "yield." The amount of waste produced in synthesizing and purifying the product was of secondary concern.

In the past decade, however, pharmaceutical companies have started designing manufacturing processes to reduce dramatically the amount of waste produced. With this change in focus, managers are tracking additional metrics, including those for green chemistry such as atom economy, energy efficiency, carbon efficiency, and E-factors. ("E-factor" is defined as the amount, in kilograms, of waste generated per kilogram of product produced.) For bulk chemicals, typical E-factors are <1–5. For pharmaceuticals, however, typical E-factors range from 25 to over 100.

One green chemistry success story comes from Pfizer, where the manufacturing process now used for sildenafil citrate (Viagra) has a very low E-factor of six. Key innovations in the development of this environmentally benign synthesis were (i) discovering a convergent, efficient synthetic route; (ii) designing seven process steps so that there was no extractive work-up in any step; and (iii) implementing efficient solvent recovery early in the product's commercial lifetime. This process earned Pfizer a U.K. Award for Green Chemical Technology in 2003.

Other pharmaceutical companies are also using the principles of green chemistry, which some scientists prefer to call "sustainable chemistry." Here in the United States, Lilly (1999), Roche (2000), Pfizer (2002), Bristol-Myers Squibb (2004), and Merck (2005) have all won EPA Presidential Green Chemistry Awards.

Berkeley ("Buzz") Cue (ACS '69) has been a leader in the pharmaceutical industry's adoption of green chemistry. Since retiring from Pfizer in 2004 as vice president of Global Research and Development, he's remained active in the field. Currently a member of the GCI Governing Board, he also served on the NRC Committee that wrote *Sustainability in the Chemical Industry.*

"It's pretty easy to make the economic case for applying green chemistry principles in manufacturing processes," Cue said. Without sustainable manufacturing processes, companies suffer a double economic penalty—purchasing raw materials that don't wind up in the final product and incurring significant costs for waste disposal.

Encouraged by the many benefits emerging from green chemistry, 11 companies earlier this year joined forces, under the GCI umbrella, to establish the Pharmaceutical Industry Roundtable. The Roundtable plans to develop a toolbox of greener synthetic methods, foster stronger industry–academe partnerships, set standards for green chemistry metrics, and sponsor conferences and educational programs.

What's Next for the Pharmaceutical Industry?

Anastas, Cue, and other green chemistry advocates believe the next step is to apply the principles at earlier stages of the R&D process—to use green chemistry in the lab, not just the manufacturing plant.

"Case studies show that applying green chemistry principles in the lab stage can save as much as a couple kilograms of raw materials for every gram of active drug that's manufactured," Cue pointed out. With R&D budgets so tight, those potential cost savings are catching the attention of more and more scientists.

And for the heavily regulated pharmaceutical industry, there's an additional reason for using green chemistry earlier in the process. "If you change the chemistry at the manufacturing stage, you can't change the quality profile of the drug without jumping through all kinds of regulatory hoops," Cue said. "You have to guarantee that the profile stays the same for patient safety and product performance considerations."

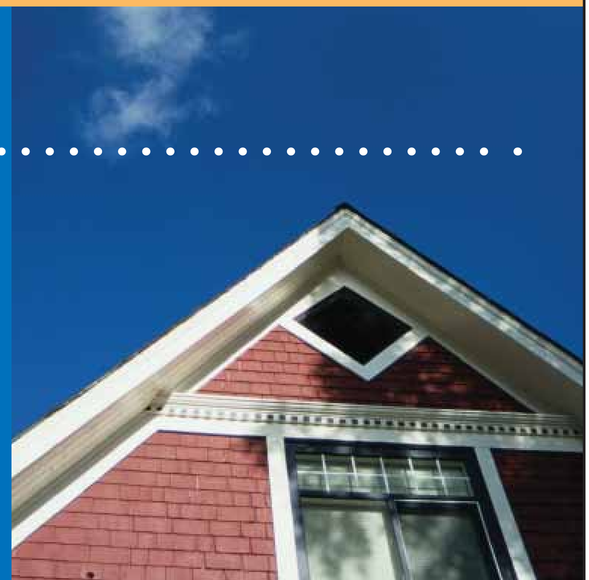
Cue's solution? "Many of us believe that all chemists should understand green chemistry principles and incorporate them into the design of the syntheses of the molecules at the earliest possible stages. Green chemistry doesn't cost extra time. They're not hard principles to learn. It's just a question of changing your mind-set."

The New Paradigm

"It's just a question of changing your mind-set." Those words from Buzz Cue aren't just buzzwords. They reflect a new vision for chemistry that's going to affect each of us in the chemistry enterprise.

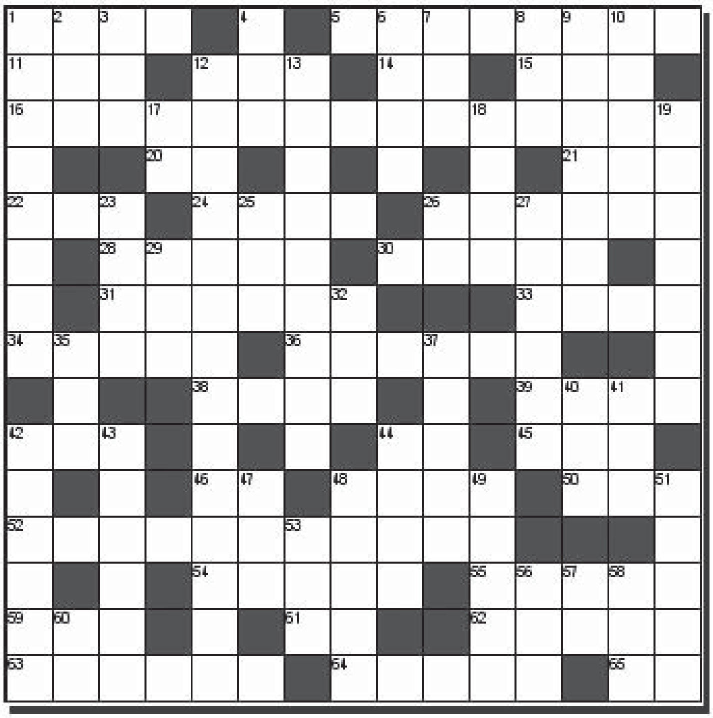
Ready to shift your paradigm? A good place to get started, right now, is to read *Sustainability in the Chemical Industry: Grand Challenges and Research Needs.*

Randy Wedin (ACS '77), Ph.D., writes from Wayzata, MN. He launched a freelance writing business, Wedin Communications, in 1992. Before that, he spent a decade "inside the Beltway," working in Washington, DC, for the ACS and as a Congressional Science Fellow.



CROSSWORD

BY MARK S. LESNEY



TRIAL SEPARATIONS

Solution to this puzzle can be found on page 39.

ACROSS

1. Sodium chloride, for example
5. Chemical table
11. Engage in diligently
12. Electric-gap-jump
14. Cobalt, for short
15. "I ____ it!"
16. Electrical separation
20. "Just __ Stories"
21. Plaything
22. Pinnacle
24. Constructed
26. Paths of planets and electrons
28. Wonderland child
30. Mollusk container
31. Near in time
33. Medicinal plant
34. Odyssean opiate
36. "Hellish" element
38. Rhymer
39. Geologic time periods
42. Ask plaintively
44. Wi__: wireless
45. Speak
46. Gaseous element, for short
48. Even longer geologic time periods
50. A sulfur-containing amino acid, for short
52. Separate into portions
54. Pertaining to kidneys
55. Carboxylate or acetate category
59. Caloric content
61. Enyzme numbering system
62. Condescend
63. Restart your chromatograph
64. Short in speech
65. Bone

DOWN

1. Of a ghost or spectrum
2. Every single one
3. Caustic chemical
4. To blow up the lab?
6. _____ cardiograph
7. Pooh's marsupial friend
8. Keats did one on a Grecian Urn
9. Purify or concentrate
10. To design an experiment so it can't be done wrong: ______ -proof.
12. Identifying elemental lines (2 words)
13. Drops out of a more kinetic state
17. Cesium, for short
18. Class of earth elements
19. Organizational groupings
23. Portion
25. Red Baron
26. Exclamation
27. Sounds loudly
29. One of the amino acids, abbreviated
32. Famous mummy
35. Rock from which metal is extracted.
37. Flame-starting quartz
40. Kind of computer memory
41. Sailor's yes
42. pH balancer
43. Scientific money sources
44. Newborn horse
47. Fib
48. Pass, as a law
49. Plant embryo containers
51. Rotates
53. Atomic number of hydrogen.
56. Look at
57. Note that goes with jam and bread
58. Freud's "self"
60. Arty network: _ & _

Dear Lab Rat,

ASK THE LAB RAT

So you've got all the answers? Try this one: What is the mass of a body at rest such that the value of the Planck constant h is 6.626 x 10^{-34} joule second? Or this one: What is the mass of (6.022 x 10^{23}/0.012) unbound carbon 12 atoms at rest in their ground state?

—A Unit on My Mind

Dear Unit,

On your mind, obviously, is the only base unit of the International System (SI) of Units still defined in terms of a museum piece—a "prototype artifact." It's the kilogram, and the artifact is the International Prototype of the Kilogram (IPK). That chunk of platinum and iridium alloy, the world standard, is kept in a safe at the International Bureau of Weights and Measures (BIPM) in Sevres, France.

As the only remaining unit based on a physical object that can change, the IPK is a constant source of irritation and frustration to the global scientific community. In fact, a new movement is afoot to finally adopt a more reliable definition of the kilogram. Check Ian Mills' excellent report in the September–October 2005 edition of IUPACs' *Chemistry International.*

In the past, other SI base units also were defined in terms of physical objects or phenomena. The old English customary system of weights and measures, for instance, defined the inch as the width of a human thumb. The foot was the length of a human foot, but eventually became longer than most human feet. In the early twelfth century, King Henry I (1100–1135) was the living standard for the yard. It was the distance from Henry's nose to the index fingertip on his outstretched arm.

The French National Assembly started to bring order and standardization to measurements in 1790, ruling that the official length of a meter would be equal to the length of a pendulum with a half-period of one second. A year later, the Assembly embraced a new meter, one equal to one ten-millionth of the length of the earth's meridian along a quadrant (one-fourth the polar circumference of the earth). A prototype artifact, a meter-long brass bar, soon replaced that.

In 1889, the first General Conference on Weights and Measures (CGPM) defined one meter as the distance between two lines on a platinum–iridium bar also kept at BIPM. CGPM was established to maintain the SI under an 1875 international agreement. The International Prototype Meter was the standard base unit of length until 1960, when CGPM replaced it with a krypton-spectrum measurement. In 1983, the current meter was defined by its relationship to the speed of light in a vacuum. One meter is the length of the path traveled by light in vacuum during a time interval of 1/299,729,458 second.

The kilogram's definition, by contrast, has been the same for almost 120 years—equal to the mass of the IPK.

And that's the problem. Science and industry need standards of weight and measure based on "invariants of nature" which are available anywhere to anyone 24/7 for calibration and other purposes. We need standards like the second—defined in terms of the hyperfine frequency of the cesium atom.

Even stored under pristine conditions, the IPK *is* changing, and so are all of its official copies stored in other countries. The IPK, made in the 1880s, is periodically weighed and compared to its official copies. The last weigh-in was in the 1980s. All the evidence suggests that the mass of *Le Grand Kilo* and its copies is drifting. It could be due to surface contamination, abrasion during handling, outgassing of material in the metal, or other factors.

The IPK apparently has lost 50 micrograms (mcg) in the last 100 years. That observed change undermines the whole idea of a standard unit of mass. A standard that weighed one kg 100 years ago should not weigh 50 mcg less today.

Two definitions, based on unvarying constants in nature, are in competition for the new standard. One is based on the Planck constant and the other on carbon-12 atoms. Mills, who has been IUPAC's representative on BIPM since 1966, lays out the pros and cons of each in his article.

After 15 years of discussing both draft definitions, Mills says the time for action is long overdue.

—A.K.A. Muridae

American Chemical Society
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IMPORTANT NOTE: You must complete the entire application. Please do not leave out information. Incomplete information will slow down your admissions process.

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ACS Approved Undergraduate Degree: ❑ Yes ❑ No

PLEASE NOTE: If you have less than a B.S. degree in chemistry, chemical engineering, or a chemistry-centered science but have significant achievement in the chemical sciences, you may be required to fill out a supplementary information form.

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We ask you to provide the following *voluntary* information. The American Chemical Society is eager to support programs that benefit underrepresented groups in the chemical sciences, and your responses are helpful to these efforts (and to *all* facets of our services to *all* of our members). Individual responses are held in strictest confidence and have no bearing on consideration for membership.

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Regular Member: A person who has a bachelor's degree in a chemical science from an ACS-approved program; a bachelor's degree in a chemical science from a non-ACS-approved program and three years work experience; an earned doctorate or masters degree in a chemical science; a full certification, licensure or other qualification as a pre-college teacher of a chemical science and three years employment as a teacher of a chemical science; or less formal training than indicated above but having significant achievement in a chemical science, may become a full member.

Associate Member: Individuals may be placed in this membership category if they have not yet met the requirements for full Society membership.

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O6APPS

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The first selection is free for first-time members; additional selections will be billed.

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- ❑ (4) Energy/Fuels
- ❑ (E) Environmental
- ❑ (L) Forensics
- ❑ (N) Geochemistry
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- ❑ (P) Inorganic Chemistry
- ❑ (13) Lubricants/Oils
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In the performance of my work, I recommend, specify, select, or purchase the following:

(check ALL that apply)

- ❑ Chemicals
- ❑ Instrumentation
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We nominate this Applicant for membership in the American Chemical Society according to the Constitution and Bylaws.

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2. ACS Member: Joseph R Peterson

Signature

Printed Name: Joseph R. Peterson
Chair
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I attest to the accuracy of the information on this application. I agree to restrict for my own personal use all publications to which I subscribe at member rates. I understand that membership dues are payable annually unless my signed resignation is received by the Executive Director of the Society prior to the end of the 12-month period for which dues have been paid.

Signature of Applicant

Date

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- ❑ Regular Member/Associate Member ($132/$190 outside North America.*)
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INSIDE ACS

For Members Only

ACS Western Regional Meeting Starts the New Year

WRM 2006 will take place in Anaheim, CA, January 22–25, 2006. Special hotel rates are available at the conference hotel, DoubleTree Anaheim/Orange. Register at the conference website (wrm2006.org) by selecting the Hotel Accommodations option or call (714) 634-4500. Use the conference code "OCL" to ensure that you receive the discount.

The theme of the meeting is "Water, Water, Everywhere!?!" It will include joint programming with the American Water Works Association (AWWA) CA–NV section; a presentation, "Water on Mars," by Kenneth Johnson of the Jet Propulsion Laboratory (JPL); and a special symposium on the impact of catastrophic flooding, which will look at the recent Gulf Coast events.

Other topics include the environment, safety issues, nanotechnology, and pharmaceuticals. The Student Affiliates are organizing exciting programming, including "Conversations with Eminent Scientists," a reception designed to permit casual conversation with leaders in chemistry. Please contact Dr. Robert Belloli (ACS '64), the Program Chair, at programchair@wrm2006.org with questions, and please check the website, www.WRM2006.org, for program updates. ⬢

INSIDE ACS

For Our Future Members

Chemistry Olympiad Invites Applications for College Mentor

The U.S. National Chemistry Olympiad program invites college educators to apply for a position as mentor. Duties during the mentor's three-year term include helping to conduct the national study camp for high school students held at the United States Air Force Academy, which is located in Colorado, during mid-June 2007, 2008, and 2009. In their second and third years, mentors generally accompany U.S. student competitors to the International Chemistry Olympiad (IChO). During the competition, the mentors will serve as members of the IChO Jury. The 2008 and 2009 IChO events are scheduled to be held in Hungary and England, respectively. The ACS sponsors the U.S. National Chemistry Olympiad program.

Most students at the study camp have completed Advanced Placement Chemistry or the equivalent; therefore, instruction at the camp goes well beyond the level of high school general chemistry courses. The curriculum also includes considerable laboratory work.

Successful applicants are expected to have a broad background in organic, theoretical, and descriptive chemistry, along with classroom experience, and should demonstrate involvement with students in special projects or activities. Applicants must be prepared to make a three-year time commitment as outlined above. ACS pays all expenses and travel costs, as well as an honorarium.

Interested individuals may obtain an application form at chemistry.org/education/olympiad.html or by requesting

an application from:

Margaret Thatcher, Senior Program Associate
U.S. National Chemistry Olympiad Program
American Chemical Society
1155 Sixteenth Street, N.W.
Washington, DC 20036
(202) 872-6328

Completed applications must be submitted by January 30, 2006. Applicants must also arrange to have three letters of reference forwarded to Cecilia Hernandez by February 6, 2006 at the above address. For more information, please call Cecilia Hernandez (ACS ’99) at (202) 872-6169.

U.S. National Chemistry Olympiad Mentor Nadine Szczepanski (ACS ’83) with students at the USAF Academy in June 2005. The Chemistry Olympiad invites college educators to apply to become mentors. The next application deadline is January 30, 2006.

INSIDE ACS

Nucleus
News from the Headquarters

Heroes of Chemistry

The annual Heroes of Chemistry awards at the 230th ACS National Meeting in Washington, DC, highlighted industrial chemists’ and chemical engineers’ contributions to their companies, the global marketplace, and the chemical enterprise.

ACS President Bill Carroll (ACS ’73) presided. He noted that like all heroes, Heroes of Chemistry save lives and change them for the better. “We at ACS celebrate them and the thousands of others who bring the benefits of chemistry to us all, every day.”

Here is the honor roll of 2005 Heroes of Chemistry.

Abdul Gaffar (ACS ’87), Colgate Palmolive, developed the technology for Colgate Total, the only FDA-approved toothpaste for controlling dental diseases.

Garland Brignac, Bruce Cook (ACS ’80), *Richard Demmin* (ACS ’86), *John Greeley, Thomas Halbert* (ACS ’80), *Jeffrey Kaufman, Mark Lapinski, Steve Mayo* (ACS ’85), *Craig McKnigh,* and *Kenneth Riley* (ACS ’64), ExxonMobil, developed SCANfining and SCANfining II, refinery processes that reduce gasoline’s sulfur content and improve air and water quality.

Hiroshi Ito (ACS ’77) and *C. Grant Willson,* IBM, developed chemically-amplified resist materials that are the universal standard for creating smaller, denser chips and microprocessors.

Ludo Kennis, Johnson & Johnson Pharmaceutical R&D, developed Risperidal, a revolutionary antipsychotic treatment that is now standard.

Peter Graf, Ulrike Pfaar, Peter Traxler, and *Jürg Zimmermann,* Novartis Institutes for Biomedical Research, developed Gleevec, a treatment that converts chronic myeloid leukemia into a treatable condition.

Since 1996, the ACS Office of Industry Relations’ Heroes of Chemistry awards have recognized chemical scientists and engineers who have developed successful

ACS Executive Director and CEO Madeleine Jacobs (ACS ’96) and ACS Chairman of the Board Jim Burke (ACS ’60) enjoying the Heroes of Chemistry Celebration at the Willard Continental Hotel in Washington, DC.

chemistry-based commercial products and innovations. It highlights their and their companies' vital role in improving human welfare.

2006 Heroes of Chemistry nominations are due February 24, 2006. Please see chemistry.org/heroes or e-mail chemhero@acs.org for more information. ⬢

Project Bookshare in Africa, Asia, and the Middle East

In Autumn 2005, the ACS Project Bookshare Center in Canton, MS shipped three 20-foot sea freight containers. Each held 20 tons of chemistry and scientific publications for an overseas institution.

Asia. As part of the *ACS Tsunami Relief Campaign,* ACS members attending the 229th National Meeting in San Diego (March 13–17, 2005) contributed money and a variety of educational materials to help *Indonesia* rebuild its science and mathematics education infrastructure. The December 26, 2004 earthquake and tsunami had devastated both. ACS used the gift funds to purchase selected teacher training materials developed by the ACS Education Division. The shipment also included donated K–12 educational materials in good condition that were published within the last five years. The shipment arrived in Jakarta on November 11, 2005.

Africa. The president of Cuttington University College in Monrovia, *Liberia* thanked ACS for its donation and noted "We are very grateful to the American Chemical Society for this donation, which is very timely, as our next semester starts on October 17, 2005."

Middle East. The president of Sana'a University in *Yemen* expressed their appreciation for the donation they received on October 29, 2005. Sharing their excitement, the head of the university related how the science faculty were celebrating the event as they unpacked the books, distributed them to the University library, and shared them with other universities in Yemen. ⬢

Inform Congress about Chemistry

Less than 5% of the 535 members of Congress have backgrounds in science and engineering. Yet every day legislators like yours are asked to make important decisions that affect our nation's scientific enterprise. You can help them make informed decisions by participating in ACS' 2006 *Contact Congress Week* (February 20–24).

Contact Congress Week is an opportune time for ACS members and local sections to meet with U.S. legislators in their district offices, attend town hall meetings, or host events at their research facilities. In 2006, *Contact Congress Week* will focus on issues relating to math and science education and federal support for research and development.

If you would like to participate in *Contact Congress Week,* please contact the ACS Office of Legislative and Government Affairs at 1-800-227-5558, ext. 4386, or at grassroots@acs.org. Participate in *Contact Congress Week* and become your legislator's "face of science." ⬢

AISES Professional of the Year

The American Indian Science & Engineering Society honored ACS Board member Nancy Jackson (ACS '79) as AISES Professional of the Year at their 27th annual national conference in Charlotte, NC, on November 3, 2005. Sandia National Laboratories' Deputy Director of International Security Programs, Dr. Jackson—who is of the Seneca tribe—also serves as a member of Sandia's American Indian Outreach Committee. Dr. Jackson delivered her award address, "The Peak of Oil Production," to 1,500 Native American high school and college students, including several ACS Scholars. She presented information about Hubbert's Peak, a predictor of the availability of vital oil resources. Her sobering illustrations pointed to a decline in oil availability coinciding with increased demand. Noting that 20% of U.S. energy is located on Native land, she challenged the students to prepare to make the complex

Robert Whitman, Chair of the AISES Board of Directors, presents Professional of the Year Award to Nancy Jackson (ACS '79).

decisions that lie ahead. Their standing ovation, the only one of the three-hour opening ceremony, seemed to indicate that they will rise to the occasion. ⬢

NCW: The Joy of Toys

Drinking Birds, Silly Putty, and Shrinky Dinks were just a few of the toys that made appearances during the National Chemistry Week (NCW) celebrations around the country. The theme, "The Joy of Toys," let us reflect upon the role that chemistry plays in toys, their development, their production, and their safety. Many also took the opportunity to note the valuable role that toys play in sparking imagination and fueling the creativity and innovation in us all.

Our own ACS President, Bill Carroll (ACS '73), took off on October 14th for his "Extreme NCW Tour." Bill managed to visit 15 cities in 10 days and covered 13,000 miles.

Many thanks to all those who participated in NCW celebrations! Next year's theme is "Your Home—It's All Built on Chemistry!" ⬢

Chemists Celebrate Earth Day

April 22 and Chemists Celebrate Earth Day (CCED) will be here before you know it! CCED is an opportunity to reach out to your community this spring with positive messages about chemistry.

The 2006 topic is "Dig It!" and ACS is creating a hands-on activity publication for CCED coordinators to distribute to school-aged children.

We encourage all local sections and student affiliates to participate in CCED's unifying event, "Plant It for the Planet." Grades K–12 may participate in an illustrated haiku contest and college students may compete in a video contest.

CCED also offers hands-on activities (available in English and Spanish), book and electronic resource lists, and contest and safety guidelines.

For details, please see the CCED website, chemistry.org/earthday. Promotional items for CCED events are available through the ACS Online Store, http://store.acs.org/cgi-bin/acsonline.storefront. For additional information, please contact the ACS Office of Community Activities at 800-227-5558, ext. 4458, or at earthday@acs.org.

Travel Awards Honor ACS Past President Fields

The legacy of Ellis K. Fields lives on. Project SEED students who were recipients of Ellis K. Fields National Meeting Travel Awards (pictured) attended the 2005 ACS Fall National Meeting in Washington, DC. Past ACS President Fields was known for his great commitment to ACS National Meetings and science education. He died July 14, 2003. His wife, Jeanette Fields, established this program in her husband's memory so that SEED students may have an opportunity to present their research at SciMix, the interdivisional poster session presented at National Meetings.

Project SEED Summer II participants from New Jersey, New York, and Pennsylvania received Ellis K. Fields National Meeting Travel Awards to attend the 230th ACS Fall National Meeting.

INSIDE ACS

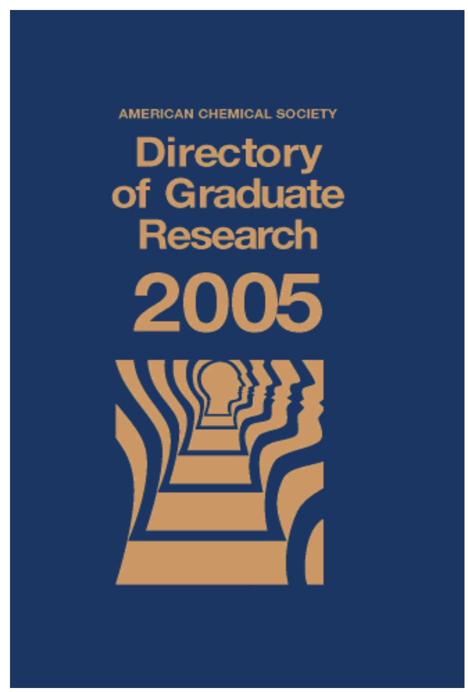
Catalyst
Opportunities for You

Are your students having trouble selecting a graduate school?

Do you need to know who is doing research that is critical to your own?

ACS may have the answers!

The *ACS Directory of Graduate Research (DGR)* 2005 continues to be the premier source of information about faculty and their research in chemistry, chemical engineering, biochemistry, and related chemical sciences programs in the United States and Canada.



New! You may now search *DGRweb 2005* free of charge. In November 2005, the ACS launched an improved *DGRweb,* which is a searchable online directory containing all of the information in the

print version of the 2005 edition of the *DGR*. With the *DGRweb 2005*, one may search for faculty and institutions by virtually any field in the *DGR*. The search feature for faculty includes specific research area, academic rank, and gender. The search results produce complete contact information for faculty that includes direct links to e-mail addresses and webpages. Institutional searches provide all departmental contact information, along with statistical data about the number of students and faculty in the department involved in graduate research. Make sure to visit this expanded resource, which is available at chemistry.org/education/DGRweb.

The printed version of the *DGR* may be ordered from the ACS Office of Society Services or the ACS Online Store. For more information about ordering, please call 1-800-227-5558 or 1-202-872-4600, or send e-mail to help@acs.org. ⬢

ACS Chemical Biology Launched

2006 marks the launch of *ACS Chemical Biology*, a new type of journal for a rapidly expanding area of research. *ACS Chemical Biology* is acting as a catalyst to foster collaboration between biologists and chemists. By publishing outstanding research of lasting impact and reaching out to the readership through a dynamic and interactive website, *ACS Chemical Biology* will sustain the intellectual needs of the chemical biology community.

ACS Chemical Biology's momentum increases with the addition of Sarah Tegen (ACS '02), formerly of *Proceedings of the National Academy of Sciences (PNAS)*, and Evelyn Jabri (ACS '98), formerly of *Nature Structural & Molecular Biology*, as Managing and Executive Editors of the new publication.

Become a pioneer in chemical biology and submit your manuscript today at www.acschemicalbiology.org. ⬢

ACS Journals Offer New Functions and Features

If you write for or subscribe to ACS journals, the ACS Publications Division has good news. You can now take advantage of new functionality and features that will save you time in citing ACS articles in your research, keeping track of what other researchers are accessing the most, and controlling when and how you view newly published articles.

Download to Citation Manager Functionality

ACS Publications launched the Download to Citation Manager functionality in 2005. This feature lets researchers download citations from ACS journals into the most commonly used citation management systems. They include EndNote, Reference Manager, ProCite, BibTex, and RefWorks.

The Download to Citation Manager feature is available on all ACS journal Full Text and Abstract HTML pages. You can find it at the top of the page, to the right of the "PDF version of this article" option. The link is called "Download to Citation Manager."

For more details about the Download to Citation Manager Functionality, please visit our Frequently Asked Questions page at http://pubs.acs.org/journals/citation/index.html.

Most-Accessed Articles Webpages

Want to find out which ACS journal articles other researchers are accessing the most? Simply go to http://pubs.acs.org/mostaccessed. Subscribers can go directly to the full text. Non-subscribers can view abstracts and purchase articles. Check back for ongoing updates to the most-accessed-articles pages for all ACS journals.

RSS Feeds for ACS Journal Articles

In 2005, RSS Feeds were implemented for the Latest News and NanoFocus features from Chemical & Engineering News Online and for the A-pages content of Analytical Chemistry, the Journal of Proteome Research, and Environmental Science & Technology. Now ACS Publications is pleased to announce that this feature is being added for all ACS journals.

What are RSS Feeds? They're an increasingly popular way for savvy web users to receive information quickly and at a glance. They provide brief snapshots of content, allowing researchers both to quickly sort through a great deal of information and to access the information as soon as it is available.

Users will need an RSS Reader to register for the ACS RSS Feeds. To register for RSS Feeds for ACS journals, look for the red "RSS" and "e-mail alerts" buttons on each of the journal homepages. These buttons will link to a main page where the URLs for all of the feeds are located. ⬢

ACS journals now offer two free notification services: E-mail Alerts and RSS Feeds.

The Dorothy and Moses Passer Education Fund Is Accepting Applications

Dorothy and Moses Passer established this fund with a generous donation. Moses (Mike) Passer headed the ACS Education Division for many years.

The Dorothy and Moses Passer Education Fund awards grants for continuing education activities to teachers at two- and four-year colleges or universities that do not offer any advanced degree programs in the chemical sciences. The continuing education activities must relate directly to the applicant's teaching and must require off-campus travel. Please note that the fund does not support general attendance at ACS national, regional, or local meetings, nor does it offer any sabbatical support.

To be eligible, faculty members must work full-time at their institutions; a committee will review their applications. Although the awards have no application form, those who wish to seek grants must submit a description of the proposed activity, along with dates, locations, titles, and contacts; the way it relates to the applicant's teaching; a brief description of the applicant's institution and department; a short curriculum vitae; an itemized estimate of expenses; the amount of aid requested, including the applicant's own funds; and sources of all supplemental funds.

The three closing dates each year are: January 1, April 1, and September 1.

The review committee greatly prefers electronic applications.

For further information or inquiries, please contact Donald E. Jones, djones@erols.com, or 3726 Connecticut Avenue, NW, Apt. 108, Washington, DC 20008.

Mark Your Calendar!

ACS National Meetings

231st, Spring, March 26–30, 2006
Atlanta, GA

232nd, Fall, Sept 10–14, 2006
San Francisco, CA

233rd, Spring, March 25–29, 2007
Chicago, IL

234th, Fall, Aug 19–23, 2007
Boston, MA

2006 ProSpectives Conferences

Process Chemistry in the Pharmaceutical Industry
March 5–8 • Miami, FL

Process Crystallization in the Pharmaceutical and Chemical Industries
April 25–27 • Philadelphia, PA

Discovery & Selection of Successful Drug Candidates
May 7–10 • Boston, MA

Applying Mechanisms of Chemical Toxicity to Predict Drug Safety
June 4–6 • Washington, DC

Successful Protein Therapeutics: The Interconnection of Formulation, Process Development, and Manufacturing
July 23–26 • San Diego, CA

Pharmacokinetics & Pharmacodynamics for Medicinal Chemists: Achieving Therapeutic Efficacy
August 20–23 • Boston, MA

2006 ACS Regional Meetings

40th Western Regional Meeting (WRM)
January 22–25 • Anaheim, CA
www.WRM2006.org

37th Central Regional Meeting (CERM)
May 17–20 • Frankenmuth, MI
www.crm2006.org/

37th Great Lakes Regional Meeting (GLRM)
May 31–June 2 • Milwaukee, WI
http://alchemy.chem.uwm.edu/GLRM06/

38th Middle Atlantic Regional Meeting (MARM)
June 4–7 • Hershey, PA
www.marm2006.org

61st Northwest Regional Meeting (NORM)
June 25–28 • Reno, NV
www.chem.unr.edu/norm06/

34th Northeast Regional Meeting (NERM)
October 5–7 • Binghamton, NY
www.nerm2006.org/

19th Rocky Mountain Regional Meeting (RMRM)
October 14–18 • Tucson, AR
www.rmacs2006.arizona.edu

41st Midwest Regional Meeting (MWRM)
October 25–27 • Quincy, IL
http://membership.acs.org/m/mwrm2006/

62nd Southwest Regional Meeting (SWRM)
October 19–22 • Houston, TX
www.chem.uh.edu/swrm06/

58th Southeast Regional Meeting (SERMACS)
November 1–4 • Augusta, GA
www.sermacs2006.org

For more information, call 800–227–5558, toll-free, or e-mail help@acs.org.

BY JAMES F. RYAN

Bruckheimer and Moonves

A new genre of television crime shows like *CSI* is presenting the public with images of chemistry and forensic science that often clash with reality.

I suppose that when the history of chemistry in the third millennium is compiled, there will have to be a section—or at least a footnote—devoted to the impact of television crime shows on the central science. Except for the Sherlock Holmes tales, previous crime stories in entertainment, ranging from Shakespeare's plays to the fictional detective Sam Spade to the television series *Dragnet,* did not depend heavily on forensic analysis. The current crop of TV crime shows is different.

Today's crime dramas can be traced back to the success of *CSI: Crime Scene Investigation,* first broadcast in the fall of 1999. Produced by Jerry Bruckheimer of *Top Gun* movie fame, the show was originally rejected by ABC television. Leslie Moonves, then head of CBS Entertainment, put it on the air. Now the progeny of this show dominate broadcast television with *CSI: Miami, CSI: New York,* and *Law & Order: Criminal Intent* to name only a few.

Each of these shows has a strong team of criminal investigators or prosecutorial attorneys. Each story depends on the careful collection of evidence followed by detailed forensic analysis. The laboratories in these shows are remarkable. Darkly lit with glass enclosed workspaces, each is equipped with computerized instrumentation and access to incredible databases. Analysis of a victim's DNA, automobile paint, or suspect saliva takes only a moment, followed by a swift cross-referencing of this information to motor vehicle records and court records. Instruments operate robotically, producing finished reports apparently capable of unquestioned admissibility to any court of law.

The *CSI* Effect

All this might seem to be just one more example of American-made melodrama except for what has come to be known as the *CSI* effect. This cultural phenomenon leads actual victims and juries to expect unequivocal forensic evidence to be presented at trial that definitively proves perpetrator guilt. No need for messy human decisions about reasonable doubt. Culpability comes from those state-of-the-art instruments with their crisp printouts of spectra and seemingly indisputable assignments of chemical identity and by implication, defendant guilt.

The *CSI* effect has also led to a substantial increase in students majoring in forensic science. One would like to think that learning the intricacies of forensic science would lead to a good understanding of analytical chemistry. A number of publishers are promoting the relationship between criminal investigations and chemistry by bringing out science textbooks with *CSI* themes. In addition, a number of institutions of higher learning are starting or enlarging forensic programs. Baylor, Pace, and West Virginia universities have all reported fast-growing undergraduate criminal investigation training programs, while the University of California at Davis and Duquesne University have begun graduate programs in this field.

The problem I see is one of expectations. Consider the textbook *Criminalistics* by Richard Saferstein (ACS '65). One of the most widely used texts in the field, it is now in its eighth edition. Six of the 18 chapters deal with topics such as organic analysis, inorganic analysis, DNA, and drug identification, each a laboratory-based subject requiring a good understanding of chemistry and chemical instrumentation. But you wouldn't know it to look at the laboratories on television shows.

Library Cocaine

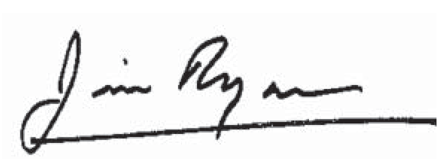
There is a story recently told to me by a friend who, from time to time, serves as an expert consultant on analytical chemistry questions in criminal and civil trials. A defense attorney in a drug possession case asked him to review mass spectral data that had been collected by a state forensic lab. One report from this lab showed two mass spectra, one above the other. The first was labeled "library cocaine" and showed characteristic ions at 82, 105, 182, 198 and a molecular ion at 303 daltons (or m/e as these units were known to those of us trained in an earlier time). The second mass spectrum was labeled "sample," and showed the same set of ions. Below the two spectra, the computer report listed a calculated match between the two spectra to be 0.99999. For all intents and purposes, the spectra were identical.

My friend the consultant then asked

how the report was generated. It turns out that it was the output of a short computer instruction sequence known as a macro. This macro had been written by one of the forensic lab staff as a timesaving shortcut that would automate the library search and computer match process. Unfortunately, the macro had been inadvertently set up to take a library spectrum and match it against itself, not against the unknown spectrum. As the report said, perfect match.

The case of course was dismissed, but more to the point, the court ordered a re-examination of all cases based on mass spectral data from this lab.

I don't want to imply that I've watched every episode of every forensic crime drama show, but in those I have seen, no one has ever run a standard sample or a blank test. I've never seen an instrument calibrated, or even the mention that these things should be done. I'm not saying that these shows should explain to us the intricacies of drafting a Standard Operating Procedures protocol, but could they at least have people write things down in a laboratory notebook? And could these dramas present the idea that at the end of the day, you have to know how an instrument operates, as well as how the data are collected and analyzed? And could they show that ultimately, someone better know how the reports are generated? Not something we've seen from Mr. Bruckheimer or Mr. Moonves yet. ⬢



Jim Ryan's (ACS '67) varied career in chemistry included seven years serving as editor of Today's Chemist at Work *magazine, where his commentary was must reading for chemists in industry. His new column appears regularly in* Chemistry.

We hope you enjoyed reading this issue of *Chemistry.*

Another great benefit of your membership in the American Chemical Society

In case you missed Jim Ryan's For Closers, click here.