Alfred Bader

Articles

1998 [articles about Bader]

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DIRECTOR'S ALERT

YOUR NEWS FROM OTHER BOARDROOMS

WHAT'S INSIDE

Adobe and Altera boards get spooked

Gone—but not forgotten. That's how directors of two California-based high-tech computer companies view Proposition 211.

Although 211 was soundly defeated last November, the boards of both **Adobe Systems Inc.** and **Altera Corp.** aren't taking any chances. They're rushing to join a list of California corporations seeking to reincorporate in Delaware. Adobe just got the go-ahead from shareholders at its annual meeting. Altera hopes to get a green light in early May.

Prop 211 is synonymous with shareholder class action pitbull **Bill Lerach** of law firm **Milberg Weiss Hynes Bershad & Lerach**. Its mission was to put directors' personal assets on the line when shareholders bring securities fraud suits. Supporters, led by Lerach, reportedly shelled out $10-$15 million to lobby for its passage. But they were outgunned by a Silicon Valley coalition which spent $40 million to crush the proposal.

"The Delaware issue came up a few times before," says Adobe director **Robert Sedgewick**, a **Princeton University** professor. "But last fall we began to take it seriously." Adobe directors and Adobe brass fear 211 will rear its head again in California. When it does, the board of this software company, that boasts $186 million in revenue, wants to be safely

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Executives put on line for company fine

Wisconsin Energy executives' wallets are a little lighter this year. The Milwaukee-based utility was forced to pay more than $400,000 in environmental fines last year. And management bonuses have been cut as a result. The compensation committee took the initiative and agreed to cut executives' incentive awards for 1996 to cover the costs of the penalties. As a result, all awards under the company's short-term bonus plan were reduced by 12.2 percent. For CEO **Richard Abdoo**, that meant a cut of about $37,000. Awards for participants employed in the affected nuclear business units were reduced by another 50 percent.

This news comes on the heels of a call from California State Treasurer **Matt Fong** for executives of **Texaco** to share part of the cost of its $115 million anti-discrimination settlement. Fong, who sits on the board of the California

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Teamsters "hit list" draws director fire

Frank Carlucci can breathe a little sigh of relief. The former secretary of defense is no longer the worst director in the country. He's the second worst. **The Teamsters** announced their second annual list of the country's "Least Valuable Directors." Carlucci was unseated by another Washingtonian, **Tony Coelho**, former House Majority whip.

Going by the Teamsters list, the recent trend to beef up boards with beltway insiders and prestigious academics is foolhardy. The number-three ranking went to former secretary of state **Lawrence Eagleburger**. **Wharton** dean **Tom Gerrity** and **Harvard** business school professor **Walter Salmon** also made the list. In addition, the Teamsters singled out for humiliation such corporate heavy hitters as **Autodesk** CEO **Carol Bartz**, **CSX** CEO **John Snow**, and for the second time **Westinghouse** CEO **Michael Jordan**.

As expected, the union used many of the

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LEAST VALUABLE *Continued from page 1*

same criteria this time around that it used for list number one (See *Director's Alert*, January 1997). Factored in were reports from compensation expert **Graef Crystal** that identify companies with low stock performance but high CEO compensation and high director pay packages. Plus the union looked at a list from the Council of Institutional Investors that spotlighted companies with long-term stock market performance problems. *BusinessWeek*'s list of the worst boards also figured into the equation. In addition, this time around the Teamsters skewered the directors if they sat on more than four boards, didn't attend 75 percent of the meetings, consulted at the company, or sat on the board of a company in bankruptcy.

"If I am responsible for poor performance, I want credit for good performance"

But some directors on the list think that the process stinks. In a letter to the Teamsters Carlucci writes: "The numbers game is easy but is a poor indicator of performance .... If ability to handle the responsibilities is what you are looking for, attendance would be much better. That is self-serving to some extent, since mine is very high on all my boards, save one, a company we own."

Former dean of the **McIntire School of Commerce at the University of Virginia**, **Bonnie Hill**, also wrote the Teamsters to correct inaccuracies in her own record. Hill, who is now a vice president at **Times Mirror**, was blasted for serving on the board of two poorly performing utilities. But Hill also serves on the boards of three thriving companies: **Hershey Foods**, **Crestar Financial**, and **AK Steel**. The Teamsters overlooked these companies in their calculations and never responded to her letter.

"If I am responsible for poor performance, I want credit for good performance," says Hill. She says that since the Teamsters misconstrued her record of service, then perhaps others on the list are wrongly singled out. "I'm considered an activist director, and I feel the Teamsters did a pretty bad job [of compiling their list]," she says.

For their part, the Teamsters admit in a disclaimer appended to the report that their judgments could be flawed. The real purpose of the list is to set tongues wagging in hopes of opening the closed doors of boardrooms. But so far the reports have had little impact. Hill says that when she found out she was on the list she called her colleagues to see if she should take some kind of action to clear her name. She says that the word that came back was, "No one pays attention to this report." ■

EXECUTIVES *Continued from page 1*

Public Employees Retirement System (**CalPERS**), has been lobbying for other institutional shareholders to join his crusade.

Is making management feel the pain the beginning of a trend? "It is not unheard of for fines for environmental violations to be factored into award decisions," comments executive compensation consultant **Dave Swinford** at **William Mercer & Company**. "What would be unusual would be if the cuts amounted to the full value of the fine," he adds. While the bonus reduction is reported in the board's compensation committee report, Wisconsin Energy is not releasing figures on the total amount of the cuts. But communications chief **Rick James** reports: "They were pretty close to being equivalent to what the fines were."

"If it were coming out of their pockets, they'd be more careful."

One big shareholder of **Sigma Aldrich Corp.** wants to nick that company's executives, too. The company paid $480,000 to settle allegations that it illegally exported toxins that could be used in biological weapons. The company had $1 billion in sales last year. **Dr. Alfred Bader** put a resolution on the company's proxy asking to make the cuts equal the fines.

Bader, a former Sigma Aldrich chairman and holder of 5.6 percent of the company's outstanding shares, wants executives to pay a pro-rata portion of the amount of fines and penalties that the company pays. He reasons that fines and penalties assessed against the St. Louis–based chemical company and the negative publicity from them hurt the company's financial performance. This in turn affects shareholder value. Executives should be accountable if something goes wrong on their watch, he argues. "That's money out of my pocket in terms of dividends," Bader asserts. "If it were coming out of their pockets, they'd be more careful."

The board argues that Bader bears a grudge against current management because he was ousted as chairman. It also claims that no other public company has such a policy. It reasons that adopting it would impede Sigma Aldrich's ability to attract management talent. ■

and Part II, "The Elements" (381 pp). The first considers the idea of the elements from Democritus to Lavoisier, the discovery and development of the periodic system, and the origin of the elements, including nucleosynthesis. The second, consisting of 23 chapters, describes each of the elements from hydrogen and its isotopes (16 pp) to the heaviest of the known transactinides (element 112). Among the topics lucidly detailed are the history; occurrence and geochemical concentration in the earth's crust; isolation or preparation; physical and chemical properties; toxicology or physiology; and the most important compounds, technologies, and industrial uses. The latest IUPAC designations are employed, and recent discoveries such as the fullerenes are included. The final chapter, 'The End of the Periodic System?", discusses the possibility of elements beyond element 112.

A 2-page color-coded periodic table and a chart of the electronic configurations of the elements are among the graphic aids included in the volume. Although no exact references are given, a list of sources is provided. Chapter designations, similar to thumb indexes, on the outer margins of the pages and an 11-page (3 columns per page) index make location of material by the reader both quick and easy. This well organized book will be of use to chemists, physicists, pharmacists, biologists, physicians, students, and anyone concerned with chemical questions. And because its author is fluent in both spoken and written English, perhaps a translation will appear sometime in the future.

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Chemical Intelligencer

Istva'n Hargittai, Ed. Springer-Verlag: New York; $29.00/year (personal subscription).

The inaugural issue of this quarterly "magazine" was January 1995. The editor and major-domo of this unique (and it is unique) publication is István Hargittai. Besides editing he often supplies some of the photographs, writes some of the articles, does some of the book reviews, and conducts interviews of people such as Pauling, Olah, Hoffmann, Fukui, Seaborg, Polanyi, Westheimer, Prelog, Lipscomb, and Ernst. I would not want to give the impression, however, that this wonderfully eclectic periodical contains only Hargittai's contributions because the scope that it has demonstrated is so huge that no one person could stretch that far.

It is described by a letter from the editor-in-chief as not another research journal but a magazine containing interesting, instructive, and entertaining articles for, among others, chemical engineers, chemistry teachers, bench chemists—just about all of us who are in, or have an interest in, chemistry. In these pages you will find history, puzzles, interesting applications of chemistry, chemical education, chemistry in the arts and humanities, and places and museums of interest to us. "Intelligencer" in an old English word meaning newspaper but it also means "one who conveys news, a secret agent or an informer", so it is as interesting as gossip but much more reliable. It is truly an international publication informing us about issues and chemical history in other countries, including emerging countries.

Alan Marchand has contributed a breezy, informative, and intriguing story of the cubane saga, which is supported by a generous array of references to the primary literature. In it he gives a quick overview of the pioneering work of Phil Eaton's group at Chicago and expands the scope to look at other adventures in cubyl derivatives from various laboratories. He discusses the practical as well as the theoretical applications of this bizarre molecule, its uses in medicine, energy, and materials. Finally, he forecasts its future applications. One can also find, in the same issue, an article on waters, super and poly, by Irvin Klotz, followed closely by Iclal Hartman's discussion of folk medicine exploring the efficacy and biochemical basis of ancient medical practices.

One of my favorites is a paper by Linus Pauling. That's right, it is a manuscript that his secretary, Dorothy Munro, transcribed from his ancient Dictaphone. It was written in 1983 at a request of an editor, to be included in a book, and it has never been published. It is entitled "The Discovery of the Alpha Helix" and is a wonderful account of how Pauling thought about the problem, who helped him to eventually see a protein molecule as an alpha helix or as the (now neglected) gamma helix form. This is just a great story about how a master goes about finding solutions to difficult problems.

More recently there can be found articles exploring the human adventures of the chemist in the corporate world. Remember the chemist who was an avid art collector and whose collection provided the covers of the Aldrich Chemical Company, now Sigma–Aldrich catalogs? He, of course, was—and happily is—Alfred Bader. He started the Aldrich Company, which was later merged with Sigma, and therein lies the basis of this strange and somewhat sordid corporate tale that led to the demise of Bader in what was his own company. It involves good old-fashioned subterfuge, misunderstanding, and hidden agendas that forced Bader to plead his case publicly to the chemical world. The piece was written by P. Bruce Buchan, a specialist in the study of the behavior of boards of directors, and since it was the board that forced Bader out it is a most informing article positing him as a victim of a way this particular board worked.

When you hear the name "Beckman" what do you think of? A DU spectrophotometer that lasts forever, right? In the latest issue of the *Chemical Intelligencer* there is a three-part article with an interview with Arnold O. Beckman, then a hearty 96 years old, a lively give and take with the irrepressible Harry Gray, the Arnold O. Beckman Professor of Chemistry and Director of the Beckman Institute at the California Institute of Technology. The article is concluded with the story of the Snub Cube, a sculpture that decorates the courtyard of the Beckman Institute.

The "Cooking Chemist" is a regular feature and so are "Notes", which are short articles about anything at all that might interest readers of this publication. The "Chemical Tourist" and the "Stamp Corner" give you some measure of the diversity of this publication.

The *Chemical Intelligencer* is a very entertaining read with enough good science in it to allow you to escape that guilty feeling when you enjoy it.

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Castle lovers: millionaire Dr Alfred Bader and his wife Isabel at Herstmonceux Castle in Sussex. Picture: NARELLE AUTIO

Dr prescribes oils

Chemist Alfred Bader buys and sells famous paintings — and he just loves giving them away

WHEN Dr Alfred Bader asked his wife if she wanted to buy a castle, he wasn't surprised when she said no, there'd be too many rooms to clean.

But he went ahead and bought it anyway for more than $8 million — and then gave it away.

Bader, 73, has had an extraordinary life, and giving away the 15th-century Herstmonceux Castle in Sussex, England is a fitting postscript to it.

His other passion is 17th century paintings, which he buys and sells as well as collecting one or two a year.

"There are not too many chemists who can say they have bought a castle and given it to a university or bought a Rembrandt and sold it to the Rijksmuseum," he says.

The Rijksmuseum is the famous gallery in Amsterdam which houses one of the greatest paintings of all, Rembrandt's *Night Watch*.

Three of Bader's old masters, including a Rembrandt, are coming to Melbourne as part of the Rembrandt exhibition at the National Gallery. The works are valued at a staggering $1.2 billion.

Canada's Queens University is the beneficiary of Herstmonceux Castle and 200ha of land, plus numerous paintings.

Although it dates from the 15th century, large parts of the castle were rebuilt this century. The grounds had been the used by the Greenwich Observatory until 1988 and the telescope buildings are still intact.

Bader's philosophy is simple. "We try to help the ablest, as well as the disadvantaged. Our last donation was $500,000 to aid the disadvantaged in Bosnia," he says.

Bader's relationship with Queens University was formed in his youth, when he was deported from England after the outbreak of World War II as an enemy alien.

Isabel Bader explains her husband's altruism as a gift from his mother. "She was always giving — until the Nazis arrived and she had nothing left to give," she says.

Bader has written about his extraordinary life in *Adventures of a Chemist Collector* (Weidenfeld and Nicolson), which details his successful business career in the US with the chemical company Sigma-Aldrich.

When he was forced out in a boardroom coup in early 1992, he devoted his time to dealing in paintings, a lifelong passion.

Isabel says the Sigma-Aldrich offices were covered in his paintings, which the employees had the right to buy at cost.

"Of course I do it for a profit," Bader says. "But love comes into it, too."

"Pictures do something to me," he explains. "When I see an Old Master's work in an auction house that has not been recognised, I feel wonderfully good."

Bader says he rarely goes to blockbuster exhibitions, preferring to be alone with a painting and "really look" at it.

But he says the Rembrandt exhibition is a wonderful opportunity for people to see a range of work from the great master.

"Some people don't have the hope of a snowball in hell of appreciating art. The nouveau riche can pay what they like to hang a canvas on their wall but that is no more than an ego trip."

He says the value of a painting has nothing to do with its cost, because of the inflated values the market can dictate.

"People should buy the best they can afford and act for their own enjoyment," he says.

That is how he began, and if people follow his example, who knows? They might end up buying a castle.

Rembrandt: A Genius and His Impact is at the National Gallery of Victoria from October 1 to December 7.

owner Michael Lord has an apartment on Madison Avenue and sometimes works as a private dealer there.

New York seems to loom as the antidote to the comparatively conservative taste of Milwaukeeans. Artist Nicholas Frank points to a place like New York's P.S. 1 Gallery and its cutting-edge shows. In Milwaukee, he says, "I found that it just wasn't possible to show the kind of work I wanted to."

To help fill that gap, Frank opened his own place, the Hermetic Gallery, and has quickly become the young Turk of the gallery scene, offering the most challenging shows in town – mostly installations of conceptual art that would have limited commercial appeal even in a city like New York.

Frank chose the name Hermetic to express his feeling of being cut off from the art world. "I was lonely here," he says. "I tried to make a community. But there are still gaping holes in the gallery scene. I've always wondered what it would be like to see a few blank pages in the middle of your magazine. That's the scene in Milwaukee."

But beyond the blank spaces, Frank finds things to like here. "It's like outer space," he says. "No one thought there was anything going on, but the scientists discovered that space has a temperature." Most of the heat Frank feels has come from galleries run by Dean Jensen and Tory Folliard.

Sobel also mentions these two, along with Frank's gallery (which Sobel loves) and those run by Michael Lord, Cissy Peltz and David Barnett. "They educate me," says Sobel. "They help me with my work. I buy work from them. They sift through work and we get to see what rises to the top. They introduce me to work I've haven't seen before."

Michael Lord opened his gallery 20 years ago, living in his shop in the early years. When he began, he did co-op advertising with six other galleries. Today, he's the only one left. "It's been a struggle, but you know, I still think of myself as starting out."

Only Folliard never mentions any struggles selling art. Her problem was getting it. "I had trouble getting the artists I liked interested in showing work at my gallery," she notes. "It took persistence."

Over time, Folliard has attracted some of the leading Wisconsin artists who were once represented by the late Dorothy Bradley – painters like Tom Uttech and John Colt. She is loyal to her artists and often travels to cities where their work is showing, rather than mooning over New York. "Artists are such terrific people," she says. "They're a lot of fun to be around." Folliard may be the only venue in town with a Web site; selections of her artists can be seen at *www.toryfolliard.com*

Many of the gallery owners began as art lovers before opening a business. Dean Jensen began as a teenage collector of multiples by such artists as Jim Dine and Joseph Beuys. After college, he became the art critic for the *Milwaukee Sentinel* but finally opened a gallery in the 1980s. Folliard began as a collector and then worked as a docent at the Milwaukee Art Museum. She began her career as a dealer working out of her home.

Probably the most interesting personal history of a Milwaukee gallery owner belongs to Alfred Bader. You can read about it in his autobiography, *Adventures of a Chemist Collector*, a 1995 book published by Weidenfeld & Nicholson in London. Bader began collecting with the purchase of a drawing in 1934, when he was a 10-year-old in Vienna. Bader, who was for many years the president and chairman of the old Sigma-Aldrich chemical company, has turned his lifelong passion for painting, especially old masters, into a gallery at the Astor Hotel.

When I spoke with him, he had just purchased a Rembrandt for $9 million, but he noted that his gallery here tended to appeal to much cheaper tastes. Some paintings are priced as low as $100. I asked him what his test for good art is. "I'm looking," he says, "for art that makes my blood pressure and my temperature go up."

I'd agree with that definition and add that Milwaukee's gallery scene, at its best, can do just that to you. "It's a great place to start out," says one local collector. "Milwaukee doesn't have any specialty galleries. The scene here provides a light smorgasbord of everything. It's a great place to start collecting art."

The smorgasbord is easiest to take in on Gallery Night, July 24, when galleries show their wares and offer free refreshments. It's a fun way to check the relative temperature of the town's best spaces for art. Here are my picks of the galleries you shouldn't miss.

Artcentric and Valenti Design Gallery, 217 N. Broadway, 220-9660. Monday-Friday 11 a.m.-5:30 p.m. Paintings, sculpture, woodcarvings, Impressionist to contemporary realism. Space works best for small shows.

Alfred Bader Fine Art, Astor Hotel, 924 E. Juneau Ave., 277-0730. By appointment only. Framed oil paintings from the 16th-20th centuries.

David Barnett Gallery, 1024 E. State St., 271-5058. Tuesday-Saturday 11 a.m.-5 p.m. Paintings displayed as in a home, in an elegant lakeside mansion. 19th-20th century masterprints and modern and contemporary art.

DeLind Fine Art, 811 N. Jefferson St., 271-8225. Monday-Friday 10 a.m.-6 p.m.; Saturday 10:30 a.m.-4:30 p.m. Bazaar-like atmosphere with a mix of realistic works, abstractions, antique posters and large, colorful animal sculptures by Dennis Pearson.

Tory Folliard Gallery, 233 N. Milwaukee St., 273-7311. Tuesday-Friday 11 a.m.-5 p.m.; Saturday 11 a.m.-4 p.m. Contemporary realism by regional and nationally known artists displayed in an attractive warehouse space.

Gallerie Art Today, 218 N. Water St., 278-1211. Tuesday-Saturday 10 a.m.-5 p.m. Contemporary European abstract art in an appealing space that works well for large-scale works.

Katie Gingrass Fine Art Gallery, 725 N. Milwaukee St., 289-0855. Monday-Saturday 10 a.m.-5 p.m.; Sunday 11 a.m.-3 p.m. Contemporary realism, wearable art and jewelry. Notable artists include printmaker John Mominee and pastel artist Jody dePew McLeane.

Hermetic Gallery, 820 E. Locust St., 264-1063. Friday-Saturday 12-4 p.m. Spunky Riverwest gallery featuring conceptual and avant-garde work, with particular focus on installations and Chicago artists.

Instinct, 725 N. Milwaukee St., 276-6363. Viewing by appointment only. Owned by a Milwaukee lawyer who became bored with the bar, this open space is a fine place to view folk and outsider art by Prophet Blackmon and others.

Dean Jensen Gallery, 165 N. Broadway, 278-7100. Tuesday-Friday 10 a.m.-6 p.m.; Saturday 10 a.m.-4 p.m. Contemporary art, photography and outsider art in a handsome storefront gallery. Jensen is particularly drawn to what he calls "eccentric figurative" art.

Michael Lord Gallery, 420 E. Wisconsin Ave., 272-1007. Monday-Saturday 10 a.m.-5 p.m. Pfister Hotel setting combines old-world feeling with modern touches. Painting, sculpture, photography and fine prints by internationally known as well as regional and local artists.

Peltz Gallery, 1119 E. Knapp St., 223-4278. Tuesday-Saturday 11 a.m.-4 p.m. Two floors of exhibition space in an 1885 Victorian house, showing contemporary paintings, pastels, wall hangings and original prints by artists like Christo, Colescott, Dine and Paschke. ■

HAILSHAM GAZETTE 22.7.98

SPOTLIGHT ON VILLAGE OF HERSTMONCEUX

Twinned with

Knight who rescued castle under siege from developers

HERSTMONCEUX Castle has had to be rescued twice this century.

The first time was in 1911 when Mr Herbeit Curteis, whose family had owned the castle since 1846, sold it to a Colonel Lowther.

He set about a complete restoration which was completed after his death by Sir Paul Latham in the 1930s.

After the departure of the Royal Greenwich Observatory in 1988, the Castle yet again came under threat, this time from developers.

This time it was Dr Alfred Bader, who in 1993 spotted a newspaper advertisement for the sale of the castle, who was the knight in shining armour who stepped in to buy it.

Dr Bader's generosity to Herstmonceux Castle was acknowledged, when on Sunday July 5, he was made a CBE by the British Ambassador in Washington on behalf of the Queen.

Dr Bader and his wife Isabel outside the castle.

Admiral Sir Lindsay Bryson, the Lord Lieutenant for East Sussex was a guest at the reception and related how Dr Bader came to England from Vienna shortly before the Second World War as one of the children of the Kindertransport.

He was a pupil at East Hove School for Boys, but was unfortunately sent to an internment camp in Canada after the outbreak of the war.

He returned to be accepted into Queen's University where he studied chemistry and began a close relationship with the college which had given him a warm welcome.

He gained a PhD at Harvard and a highly successful career in the field of the manufacture of fine chemicals in the United States followed. He also holds a doctorate from Sussex University.

Dr Bader has always kept in touch with Sussex through his very happy marraige with Dr Isabel Bader, who comes from Bexhill. They have a house there, but their main home is in Milwaukee.

Art whiz Bader runs small-scale gallery

BY JAMES AUER
Journal Sentinel art critic

"Please bother me," pleads chemist and art collector Alfred Bader in an advertisement in The Amalgamator, journal of the Milwaukee Section of the American Chemical Society.

Bader, the self-styled "art detective" who founded Aldrich Chemical Co. in 1951 and served as chairman emeritus of its successor, Sigma Aldrich Corp., until 1992, says he enjoys being bothered at his small but elegant gallery in the Astor Hotel. But only by appointment.

"We're the best-kept secret in town," says the 72-year-old art dealer and connoisseur, an internationally recognized authority on Old Masters who divides his time between our town's upper east side and a house he and his wife, Isabel, own an hour or so outside London.

Bader will be sharing some of his expertise — and possibly revealing a secret or two — Thursday evening as he speaks on the topic "The Joy of Collecting: Hunting for Old Masters," in the East Entrance of the Milwaukee Art Museum, 750 N. Lincoln Memorial Drive.

It will be the American premiere of this particular lecture, one of 10 on the industrious art enthusiast's "menu" of available programs. He first tried it out at the Art Gallery of Ontario, Ottawa. Socializing is at 6 p.m., dinner at 7, the illustrated talk at 8.

The meeting, which also includes guided gallery tours, is sponsored by the Milwaukee Section of the American Chemical Society. Specially invited guests are members of the Fine Arts Society, an art-museum support group. Tickets are $20, $10 for chemistry students.

Milwaukee isn't the hottest market for purveyors of Old Masters, admits Bader, who was born in Austria and is now a U.S. citizen. Still, he does quite well, showing pictures to patrons on request and selling major works to museums and collectors in the United States and abroad.

"Last year," he says, "I sold a beautiful picture by Paulus Potter for $2 million to the Art Institute of Chicago. I also bought a Rembrandt from a bank in Geneva. It's now in a collection in Germany."

Occasionally, he says, he will buy a picture at the request of a particular museum, then hold it until the museum has had a chance to put together enough money to buy it.

Dealers such as himself often have greater financial flexibility than non-profit institutions.

Right now, he's looking forward to attending auctions of vintage European paintings on both sides of the Atlantic.

A portrait of a gentleman, by Rembrandt, has caught his eye. So has a particularly spectacular — and very rare — El Greco. Will he bid? Only the gods know.

One thing is certain: For all his devotion to quality, Alfred Bader is no snob, fiscally speaking. Pictures hanging in his gallery range in price from $100 to $200,000. "If you come in looking for a wedding gift for $250, I'll show you several possibilities," he says.

Furthermore, he handles things that range from "17th-century to contemporary." He buys up to 200 pictures a year, of which "two or three" go into his own collection. The remainder he passes on to new owners. He delights in introducing people to the joys of collecting.

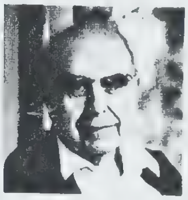
Keeping up with the market — what's available, what's authentic, what's desirable, what's affordable — takes lots of study, and Bader seldom is without a book or magazine, at home or while traveling. "Other people look at TV," he admits with a grin. "I read art books."

Philanthropy also occupies much of Bader's time. He concentrates his giving on inner-city causes, particularly better education for children. He also aids recent immigrants to Israel. He has given 140 Old Master paintings to his alma mater, Queens University, Kingston, Ontario.

In contrast to Sigma Aldrich, which in 1997 reported total sales of more than $1 billion, Alfred Bader Fine Art is a very small enterprise. Still, it commands its director's interest. "I'm happier today than I was 10 years ago," he says. "Today, I pick my friends."

Alfred Bader Fine Art, in the Astor Hotel, 924 E. Juneau Ave., has no regular viewing hours but is open to the public by appointment. Call (414) 277-0730 for details. Admission is free.

Personal news



Dr A. R. Bader, HonFRSC (*left*), founder of Sigma-Aldrich, art collector, philanthropist and ambassador for chemistry, has been awarded an honorary CBE

Education

Prof R. Breslow, S. L. Mitchill professor of chemistry at Columbia University, is to receive the 1999 ACS Priestly medal for distinguished service to chemistry. **Dr J. M. O'Brien**, CChem, MRSC, lecturer in food safety at the University of Surrey, has been appointed academic editor of *Trends in Food Science and Technology*. **Prof P. A. Sermon**, CChem, FRSC, has been appointed professor of physical chemistry at the University of Surrey.

Industry

Dr C. T. Evans, OBE, CChem, FRSC, biotechnology entrepreneur and founder of Chiroscience, has been awarded the 1998 Society of Chemical Industry Centenary medal

Deaths

Atkinson, Prof George Francis, CChem, FRSC, formerly professor of chemistry at the University of Waterloo, Ontario, Canada, died 17 February 1998, aged 65

Barton, Prof Sir Derek Harold Richard, CChem, HonFRSC, FRSE, FRS, professor of chemistry at Texas A & M University, Texas, US, died 16 March 1998, aged 79 (*see below*)

Butt, Leonard, Thomas, CChem, MRSC, retired, died 10 April 1998, aged 74

Clark, Dr Edmund Roy, CChem, FRSC, retired chemistry lecturer at the University of Aston, Birmingham, died 3 February 1998, aged 70.

Coxon, John, CChem, FRSC, retired, died 16 February 1998, aged 82

Dakin, Howard Granville, CChem, MRSC, formerly self-employed sales consultant, died 4 March 1998, aged 59

Edwards, Percival Rowland, CChem, MRSC, retired chief chemist at W. Symington, died 9 March 1998, aged 95

Edwards, Ronald Leslie, CChem, FRSC, retired scientific and technical consultant to the mushroom industry, died 5 April 1998, aged 87

Ellinger, Dr Leo Philipp, CChem, FRSC, retired, died 12 March 1998, aged 80

Fletcher, Archibald William, CChem, FRSC, retired, formerly with Duval, T
US, died 2 February 1998, ag

Frew, Robert Hunter, LRSC
March 1998, aged 76

Green, Bernard Jeffrey, CCh
retired principal research eng
Central Research Laboratory, H
March 1998, aged 66

Grice, Prof Robert, formerly
physical chemistry at the Univ
Manchester, died 11 March 19

Haase, Dr Rolf, formerly eme
chemistry at the Technical Uni
Germany, died 9 July 1997, ag

Hall, Michael Lister, CChem,
group manager at British Nucl
Windscale, Cumbria, died 11 M
aged 71.

Harris, Roy, CChem, MRSC
managing director at Eurothar
died 21 January 1998, aged 53

Jones, Dr William Reginald,
chemist at Glaxo Group Researc
died 16 February 1998, aged 58

Nicholls, John Jonas, CChem
operations improvement mana
Chemicals International, died 2
1998, aged 85

Roberts, Mark Grey, LRSC, ret
Shell Research Centre, Chester, d
1998, aged 51

Jack Barrett 1912–98

For over half a century, Dr Jack Wheeler Barrett was one of the country's leading technologists, at Monsanto, where he ended up as director of research, and then in later life, as chairman at R. H. Cole (later Cole Group). He possessed a unique combination of academic prowess and commercial acumen, evidenced by his having served as president of three learned and professional societies (the Institution of Chemical Engineers in 1971, the Chemical Society in 1975, and the Institution of Information Scientists in 1976).

Barrett was born in Cheltenham into a family of farming stock. He went on to graduate with first class honours in chemistry from the Royal College of Science, Imperial College. A problem then confronted him as to the field he should adopt for his PhD – should it be organic chemistry or chemical technology (later chemical engineering)? In view of the path that his career subsequently took, it was perhaps surprising that he opted for organic chemistry. Notwithstanding, on completion of his PhD he chose to embark on an industrial career, joining Monsanto Chemicals in 1941 at its Ruabon Laboratories.

Barrett clearly relished the challenging world of first class technical development in a multinational environment. By 1950, he was general manager of research, and five years later, he joined the board as director of research. During this time, Monsanto grew rapidly, and Barrett was able to apply his considerable energy to bring out production plants for poly(styrene), poly(ethylene), maleic anhydride and even crystal silicon. With time, his role at Monsanto became more international in nature, with activities in Europe and liaison work with US headquarters.

It was two years after his retirement from Monsanto that Barrett was approached to take the chair at R. H. Cole, a plastic company with divisions in plastic conversion, dental polymers, electronic engineering and trading operations. His vigour knew no bounds, and having analysed the problems of the group, his personal magnetism enabled the necessary changes to be pushed through, such that the now very profitable group was sold after eight years, giving good value to the Cole shareholders.

In addition to Barrett's tireless service as president of three professional societies, he was treasurer of the Chemical Society, founder president of the Industrial Division of the Chemical Society, a member of the IUPAC Bureau, chairman of the Royal Society of Chemistry's BOC Priestley Conferences Committee, a member of the British Library board and chairman of the London section of the Society of Chemical Industry. Primarily as a result of this service, he was awarded the CBE in the Queen's Birthday Honours in 1971.

And what of Jack Barrett the man? – an avid and enthusiastic gardener, a delightful host at dinner parties at The Athenaeum, where he liked nothing better than having debates with scientists and industrialists on issues great and small – a man who enjoyed life and lived it to its full. He was a person of whom it can genuinely be said that the world is a poorer place for his being no longer with us, and he will be remembered with a very great deal of affection by a

Sir Derek Barton 1918–98

There was organic chemistry before Derek Barton, as there will be after him, but for most of us Barton has always been there, brilliantly dominating the scene. For 50 years he has set a standard of quality and productivity, and
changed the subject profoundly
insight and prodigious knowledg

In 1940, Derek Harold Richard B
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to Texas A&M University (1986
equally well in all these different
so, from those brilliant early days u
1998, in his 80th

Toast the Top 75

at the ACS National Meeting in Boston

Come meet and be photographed with 23 of C&EN's Top 75 Contributors, selected in a reader poll and announced in the Jan. 12, 1998, issue of C&EN. ACS President Paul H. L. Walter and ACS Board Chair Joan E. Shields will present them with medals in recognition of their contributions. Refreshments and a C&EN 75th anniversary cake will be served, 4–6 p.m., Sunday, Aug. 23, Fairmont Copley Plaza Grand Ballroom.

Pictured above from left to right: Alfred Bader, Ronald Breslow, Herbert Brown, E. J. Corey, F. Albert Cotton, Carl Djerassi, (second row) Ernest Eliel, Gertrude Elion, Mary Good, Harry Gray, Dudley Herschbach, Roald Hoffmann, (third row) Ralph Landau, Rudolph Marcus, Samuel Massie Jr., Bruce Merrifield, George Olah, John Roberts, (fourth row) Glenn Seaborg, K. Barry Sharpless, Gilbert Stork, Henry Taube, Frank Westheimer


JANUARY 12, 1998
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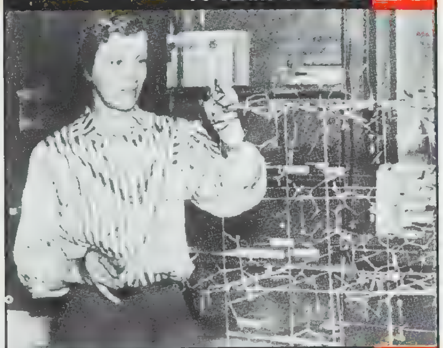

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CHEMICAL & ENGINEERING NEWS

The newsmagazine of the chemical world

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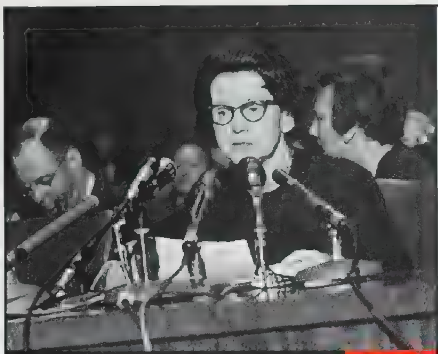
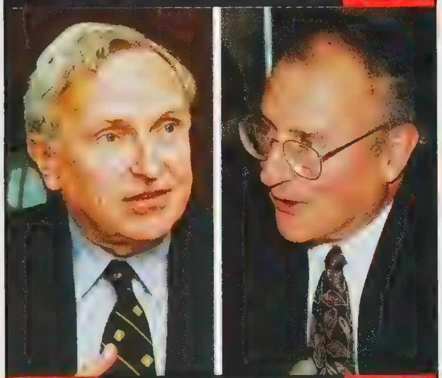
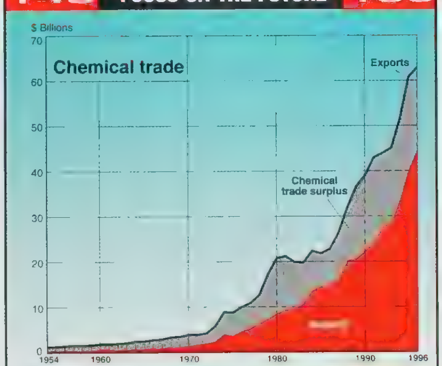
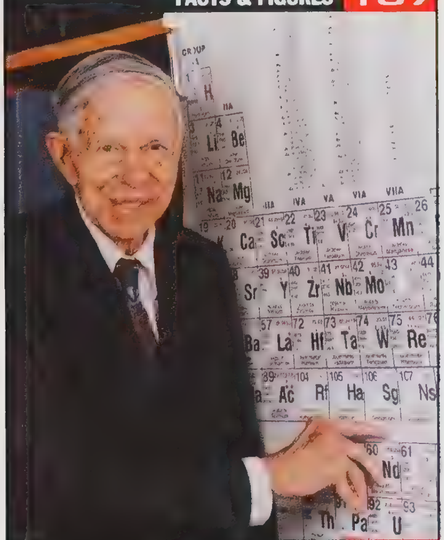
75th Anniversary Special Issue









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▸EDITORS' PAGE

75 Years And Counting

This issue marks the diamond anniversary of *Chemical & Engineering News*, which began life as the News Edition of *Industrial & Engineering Chemistry* on Jan. 10, 1923. We are pleased to note that it's been a long, productive, and fascinating life thus far.

Indeed, C&EN has existed throughout a period of remarkable growth and vitality in the chemical enterprise—a period during which chemistry has changed the face of the world. This special issue is devoted to capturing the substance and flavor of those 75 years.

We began planning for this special issue more than a year ago. We wanted to provide C&EN's readers with a true keepsake—an extensive, substantive, and lively publication that would not only document the history of the chemical enterprise but look ahead to its future. Our goal has been to bring attention to the important contributions that chemists, chemical engineers, and chemical entrepreneurs in industry, academe, and government have made to society at large.

Many people contributed to making this special issue possible. At some level, the entire multitalented staff of C&EN, aided by the Graphics & Production Department, worked on this issue. Under exceptionally tight deadlines, Brown Printing produced a beautiful publication on heavier-than-normal paper so that your individual perfect-bound copy will have a long shelf life.

The interest in this special issue has been gratifying. Thanks to our corporate advertisers and the outstanding work of our advertising sales group, Centcom Ltd., this issue is perhaps the largest in C&EN's history.

We especially want to thank the American Chemical Society and the loyal readers of C&EN, who have made it possible for us to reach our 75th year of existence. As editors, we are very proud to be at the helm of this publication as it celebrates its diamond anniversary. At our headquarters in Washington, D.C., and at six news bureaus around the globe, we have tried to reinvent the magazine each week to keep it accurate, timely, captivating, and concise. We pledge that we will continue to live up to our slogan, "The newsmagazine of the chemical world," by keeping you abreast of the latest news, trends, and insights in the diverse and vibrant chemical enterprise.

Madeleine Jacobs
Editor

Rudy M. Baum
Managing Editor

Views expressed on this page are those of the authors and not necessarily those of ACS


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CIRCLE 5 ON READER SERVICE CARD

▸GREETINGS FROM THE ACS OFFICERS

The American Chemical Society is many things to its 156,000 members. To some, it is the journals; to others, the local section; to still others, the national meeting; but to all it is *Chemical & Engineering News.* C&EN is the glue that holds our diverse group together. For 75 years, chemists in industry, government, and academe have been united through this publication. As a boy, before I was eligible for membership in ACS, I would borrow copies from chemist friends, or sit in the library keeping up with what was new in the profession I hoped to join. Obviously, the "glue" stuck to me as I'm certain it did to many of our members. In its first 75 years, C&EN has become essential reading for American chemists—both members and nonmembers. May the next 75 years see C&EN join its sister publication *Chemical Abstracts* as essential reading for chemists worldwide.

Paul H. L. Walter

Paul H. L. Walter
ACS President

In the company of chemical scientists, what do we think of when we hear the number 75? Some of us would turn to the periodic table and discover rhenium, a rare element with the symbol ***Re.*** But the number 75 also represents the glorious anniversary of C&EN. For me, the symbol ***Re*** is also appropriate as the first two letters of the word, "***Re***ad." By a simple computation, I have discovered that, as a 42-year-member of ACS, I have ***Re***ad over 2,000 issues of C&EN. For me, as for all the members of our society, it has been a wonderful ***Re***ad. Bravo and congratulations! Let us hope that C&EN will continue to be ***Re***ad for centuries to come. For all of our members and for nonmember readers, it is a symbol of excellence. Happy 75th anniversary!

Joan E. Shields

Joan E. Shields
Chair, ACS Board of Directors

In all of the surveys of ACS members, one service has consistently stood out as meeting the needs of nearly all its members—*Chemical & Engineering News,* the official organ of the world's largest scientific society. Although C&EN is not the oldest ACS publication, it is certainly now its flagship product, the one publication that every member—and many nonmembers—receive and must read to keep them apprised of the entire spectrum of chemical news affecting their careers and lives as well as news of the society. No other chemical publication covers the entire range of news of interest to our profession with the accuracy, timeliness, and insightfulness of C&EN. As someone who has worked at ACS for more than 30 years, I am proud to extend congratulations to the entire editorial and advertising staff of C&EN for making it "The Newsmagazine of the Chemical World." May you continue to achieve many more years of great chemistry.

John K Crum

John K Crum
ACS Executive Director

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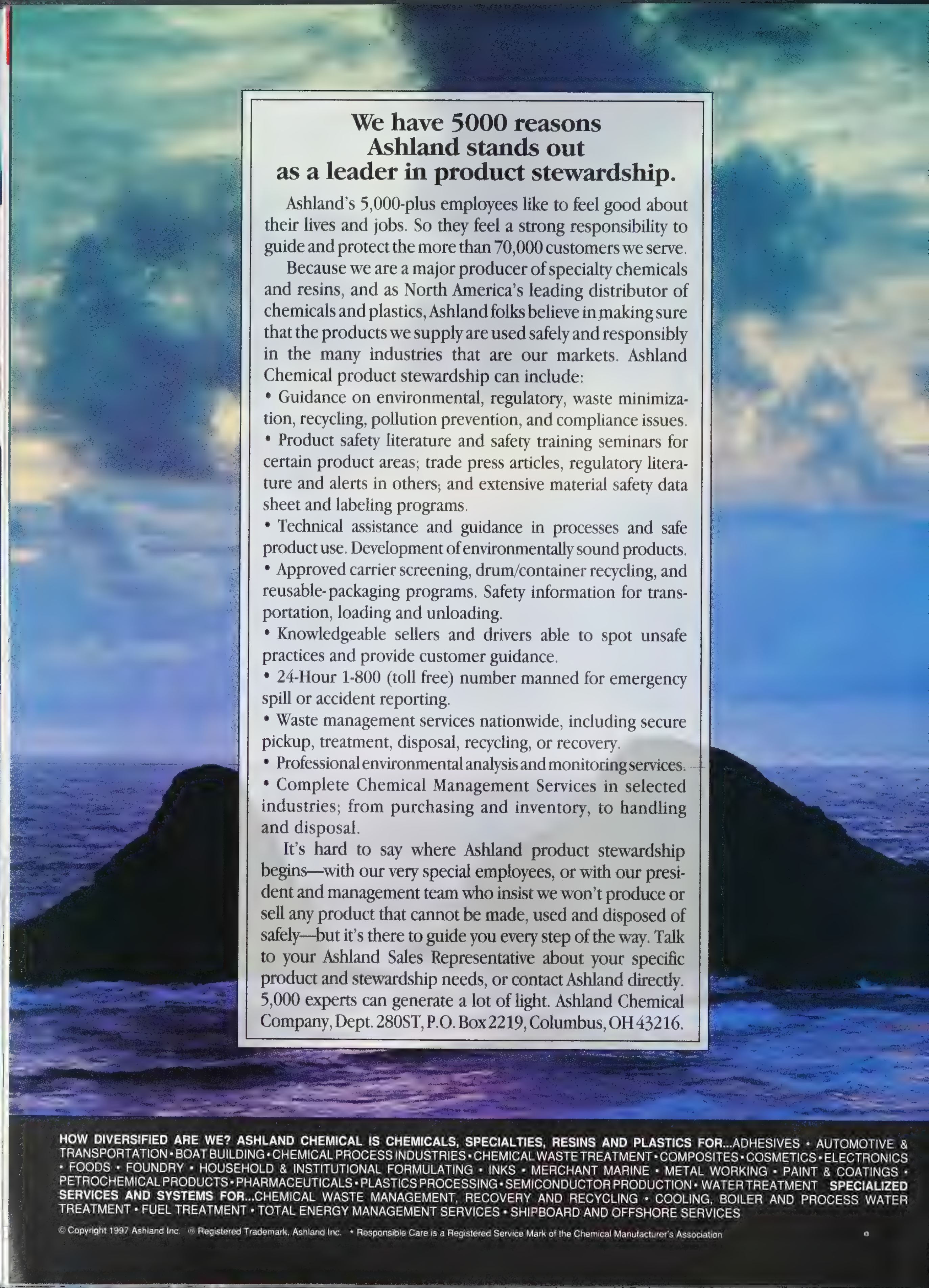

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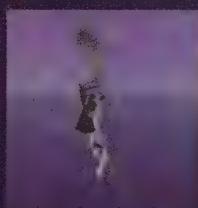

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ODORANT RECEPTOR MATCHED TO ODORS

Researchers determine compounds that activate a specific odorant receptor

By forcing rats' noses to make large amounts of a particular odorant receptor, researchers for the first time have been able to match a specific odorant receptor to the compounds it responds to. The work should lead to solutions of one big puzzle in the understanding of the sense of smell: the specificity of receptors and the nature of the information they send to the brain.

Genes for odorant receptors were first cloned in 1991, but many attempts to produce functional receptors in surrogate cells have been unsuccessful. Although surrogate cells can express the genes and assemble the proteins, apparently they lack other factors the receptor needs to send a signal to the brain.

Yale University graduate student Haiqing Zhao, Columbia University associate professor of biology Stuart Firestein, and coworkers at Columbia and at the Molecular Neurobiology Laboratory, Tsukuba Life Sciences Center, Tsukuba, Japan, have circumvented these problems by using cells that naturally express odorant receptors in the first place. This novel approach has led to expression of one working odorant receptor, called I7, in the noses of rats. And the researchers have found that among 74 compounds tested, I7 responds significantly to only four aldehydes—heptanal (C_7) through decanal (C_{10}) [*Science,* **279,** 237 (1998)].

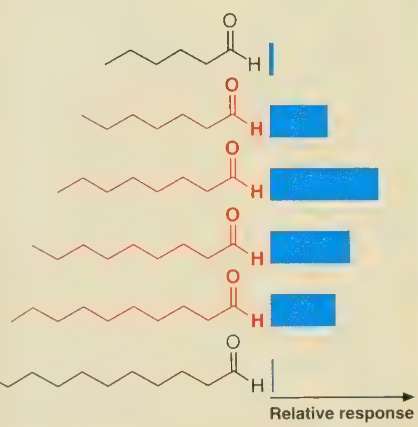
"Our strategy, devised by Zhao, was to identify a cell type that we knew could express the receptors," says Firestein. "[Zhao] reasoned, simply enough, that the best cells would be olfactory neurons, because that's what they do."

The trick was to get olfactory neurons to express a specific receptor instead of the one they normally do, and to have many neurons expressing the same receptor. Because a virus naturally forces the cell it infects to produce viral protein rather than the protein the cell makes for itself, the researchers used an adenovirus to deceive the olfactory neurons.

The researchers infected live rats with a virus containing the gene for I7 and the gene for a fluorescent protein so they could find the olfactory neurons expressing I7. When they shine a blue light inside the animal's nasal cavity three or five days after infection, the areas with the receptor light up green. And by inserting electrodes on the fluorescent tissues, they can measure the electrical signals of I7 in the presence of an odorant.

The work "is a breakthrough," says Linda B. Buck, an associate professor of neurobiology at Harvard Medical School and an associate investigator of the Howard Hughes Medical Institute (HHMI). "It allows us to ask detailed questions about what individual receptors recognize, to learn how the amino acid sequences of receptors relate to their functional capacities, and to examine whether information from different receptors that is sent to different parts of the brain can be correlated with particular odorants."

Receptor responds to only a few aldehydes



Note: Among 74 compounds tested, only the highlighted aldehydes significantly increased receptor response.

Firestein: can begin to learn the rules

Buck discovered the odorant receptors and initially cloned the genes, including those encoding I7, while working with HHMI investigator and Columbia biochemistry and biophysics professor Richard Axel. Subsequent studies in her lab and in Axel's have led to an understanding of how the olfactory system works—including the distribution of receptors and how information is organized and moves from the nose to the brain (C&EN, Dec. 23, 1996, page 18). When that knowledge is combined with information about receptor specificity, she says, "we will have a fuller picture of how information about different odorants is encoded and routed in the nervous system."

While the work with rats may be a breakthrough, it may not necessarily be a first in functional expression. Several years ago, a group in Germany reported the cloning of odorant receptor genes and their expression in surrogate cells infected with baculovirus [*Nature,* **361,** 353 (1993)]. Both Buck and Firestein tell C&EN that other researchers have found it difficult to replicate the work, perhaps because of the complexity of the assay system that was used.

Although there are only 500 to 1,000 odorant receptors, humans can recognize far more than 1,000 discrete odors. Clearly, combinatorial processing is at work, with one receptor responding to several odorants and one odorant triggering various receptors. With a method now for expressing single functional odorant receptors, researchers can begin to think about screening receptors to determine their specificity.

Even if all odorant receptors are expressed and testable, the sheer number of odorant compounds will make screening a marathon task. "Right now, we do it odor by odor," says Firestein. "We believe eventually we will be able to use cocktails of odors."

In addition, "the expectation is that there will be some rules here, that it's not entirely random," says Firestein. "After a few dozen receptors and a few hundred odors, we think we'll begin to learn some of the rules and make predictions."

Maureen Rouhi

Elementis buys Rheox from NL Industries

NL Industries of Houston has agreed to sell its Rheox additives subsidiary to London-based Elementis for $465 million. The transaction provides significant expansion opportunities for both buyer and seller.

Harrisons & Crosfield, which became Elementis on Jan. 1, not only starts the new year with a fresh name, but also has clinched a deal that furthers its efforts to remake itself into a specialty chemicals company from a diversified one.

And the sale will provide NL Industries with cash it could use to pay down debt and enlarge its Kronos titanium dioxide subsidiary through the purchase of partner ICI's share in Louisiana Pigments.

"With this acquisition, Elementis is now a fully credible international specialty chemicals group with a clear focus," says Elementis Chairman Jonathan Fry. Elementis acquires 370 people and manufacturing facilities in St. Louis; Charleston, W.Va.; and Livingston, Scotland; as well as a hectorite clays mine in Newberry Springs, Calif.

Elementis had 1996 sales of $3.3 billion, of which chemical sales were $965 million. It is in the process of selling its poorly performing timber, building supplies, food, and agriculture businesses. To date, Elementis has raised $780.8 million in the sale of noncore businesses.

The acquisition of Rheox, a Hightstown, N.J.-based maker of rheological additives for industrial coatings with 1996 sales of $135 million, will enlarge Elementis' chemical operations. Those operations now include chromium chemicals, pigments, polymer colorants and additives, and the Akcros joint venture in specialty organic chemicals for coatings, inks, and adhesives with Akzo Nobel.

David Ingles, chemicals analyst for the London-based investment bank HSBC James Capel, says the Rheox deal is "an essential acquisition" for Elementis to transform itself into a specialty chemicals company. Though the company is paying "a fairly full price" for Rheox, the price is not out of line with the high prices others have paid recently for specialty chemicals companies—such as the $8 billion ICI paid last year for the Unilever specialty chemicals businesses.

According to J. Landis Martin, NL Industries' chief executive officer, "The sale of Rheox enables us to acquire additional TiO_2 capacity at a time we believe is early in the recovery of TiO_2 prices." NL Industries' chief financial officer, Joseph S. Compofelice, confirms that the company wants to acquire 100% ownership of the 50-50 joint venture with ICI in Louisiana Pigments.

If NL Industries succeeds in purchasing Louisiana Pigments, it could put DuPont, the world's largest TiO_2 maker, in the interesting position of subsidizing a competitor. When ICI agreed to sell its global TiO_2 business except for North American operations to DuPont in July 1997, DuPont agreed to cover any deficit if ICI sold those operations for less than $150 million.

Marc Reisch

Painkiller acts on nicotine receptor

A potential pain drug synthesized by scientists at Abbott Laboratories, Abbott Park, Ill., knocks out pain more effective-

Destination: The moon

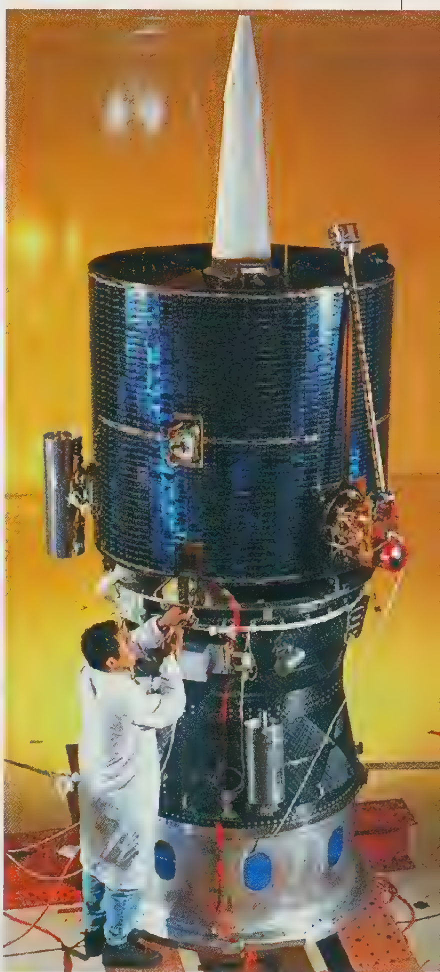
This week, if all goes as planned, the *Lunar Prospector* spacecraft (atop lunar injection stage, right) will begin its one-year mapping mission of the moon, mere days after a successful Jan. 6 launch from Cape Canaveral. And within weeks or even days, scientists could finally have in hand the answer to the tantalizing question: Does water exist on the moon?

Last year, scientists announced that radar data from the Department of Defense's Clementine mission, which flew by the moon in 1994, suggested that water ice may lie inside permanently shaded craters at the moon's poles. That led to much speculation about the possibility of using the ice to sustain life on lunar colonies, and of harnessing lunar hydrogen for rocket fuel.

***Lunar Prospector's* neutron spectrometer—one of six instruments aboard the craft—can detect the presence of hydrogen and, therefore, water by measuring characteristic energies of neutrons recoiling from collisions with hydrogen. The neutrons are generated by cosmic rays striking the moon's surface. The craft also will measure the moon's magnetic and gravitational fields and characterize its surface composition.**

The $63 million Lunar Prospector mission is the third of the National Aeronautics & Space Administration's Discovery series—quick, inexpensive space missions that include the wildly successful *Mars Pathfinder*.

Elizabeth Wilson



NASA photo

ly than morphine. In animal studies, the compound—ABT-594—doesn't cause withdrawal symptoms like opiates. Unlike morphine, ABT-594 acts through nicotine receptors in nerves rather than opioid receptors [*Science,* **279,** 77 (1998)].

The feat is exciting, says Christopher M. Flores, assistant professor of endodontics and pharmacology at the University of Texas Health Science Center, San Antonio. "ABT-594 represents a new class of analgesic compounds that are nonopioid in nature, raising the possibility of discovering drugs that lack morphine's adverse side effects."

ABT-594 resembles the alkaloid epibatidine that National Institutes of Health scientist John W. Daly isolated in 1976 from the skin of an Ecuadorian frog. A potent analgesic in animals, epibatidine's side effects preclude its use in humans. "Abbott has done a fantastic job" in developing a variant with the potential to be clinically useful, Daly says.

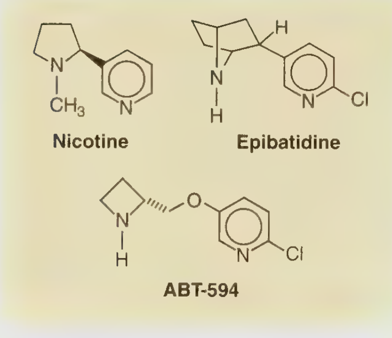
Both ABT-594 and epibatidine have similar affinities for a nicotine receptor subtype that predominates in the central nervous system. But ABT-594 is 4,000 times less efficient than epibatidine in binding to nicotine receptors at the neuromuscular junction. That explains why the Abbott compound doesn't have epibatidine's adverse neuromuscular side effects, such as paralysis.

In various experiments, the Abbott research team showed that ABT-594 modulates pain via pathways in the brain and spinal cord as well as at the peripheral end of pain-sensing nerves. "I think that's one of the reasons ABT-594 is such a good [painkilling] agent," says Abbott neuropharmacologist Stephen P. Arneric. "It works at multiple sites."

Other pain researchers are cautiously optimistic. "The [Abbott] research is definitely worth following up on, but there's lots more to do," says Allan I. Basbaum, chairman of the anatomy department at the University of California, San Francisco.

Arneric agrees. "People have been working on opioids for the past several decades, whereas the work on ABT-594 represents basically two years of research," he points out. "So many questions have not yet been answered."

One of these questions is whether the compound could evoke a nicotine-like dependency. Flores notes, however, that an ABT-594 variant that would selectively target pain-sensing sites in the periphery "would get around the issue of dependence, a phenomenon largely mediated in the brain."



There are other hurdles. Getting the Food & Drug Administration to approve an analgesic drug is extraordinarily difficult, says Tony L. Yaksh, vice chairman for research in the department of anesthesiology at the University of California, San Diego. "The drug must have the ability to alter pain in a way other drugs cannot."

But Yaksh sees a bright side. "Whether or not ABT-594 makes it through clinical trials," he says, "it represents a fundamentally novel mechanism" for modulating pain.

Mairin Brennan

Sulfur-radical theory may aid oil exploration

Models for predicting the location of oil and natural gas deposits may have to be modified now that experimental evidence shows sulfur radicals play a key role in controlling the rate of petroleum formation.

Michael D. Lewan, a research organic geochemist at the U.S. Geological Survey, Denver, has proposed a model to account for the numerous hydrocarbon fragments found in petroleum [*Nature,* **391,** 164 (1998)]. These fragments are formed during petroleum generation through the thermal decomposition of kerogen, the insoluble organic material buried in sedimentary basins.

"Conventional wisdom advocates that it is the weakness of C–S and S–S bonds that is responsible for early petroleum generation from sulfur-rich kerogen," Jeffrey S. Seewald, a geochemist at Woods Hole Oceanographic Institution in Massachusetts, tells C&EN.

But according to Lewan, that explanation fails to account for the overall composition of petroleum. He argues that the rate of petroleum formation depends critically on the concentration of sulfur radicals formed during the early stages of thermal maturation. He suggests that early petroleum generation from sulfur-rich kerogens results from enhanced rates of C–C bond cleavage due to an abundance of sulfur radicals that may initiate free-radical cracking.

Lewan's hypothesis is based on pyrolysis experiments on 1-phenyldodecane (PDD) containing varying concentrations of diethyldisulfide (DEDS). "PDD is commonly used as a model compound for coal and kerogen, and DEDS is a good source of sulfur radicals like those found in kerogen," he tells C&EN. The experiments were carried out in isothermal closed-system reactors with and without water at temperatures up to 365 °C over hours to several days.

The results show that PDD degradation increases with increasing amounts of DEDS. "My findings provide petroleum geochemists with a first approximation of the kinetic parameters for petroleum generation from a source rock based on its organic sulfur content," says Lewan.

Seewald, who comments on the research in the same issue of *Nature,* points out that the conditions Lewan uses are important. "They facilitate secondary reactions between alteration products and initial reactants and therefore more closely replicate conditions in natural systems where alteration products are not rapidly removed from the site of generation," he says.

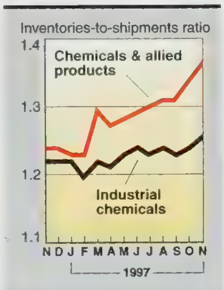
Lewan notes that his results "imply that kinetic parameters determined by nonisothermal open-system pyrolysis, which are commonly employed in petroleum exploration, are not applicable to petroleum formation in sedimentary basins."

Seewald explains that predictive models used by the oil industry generally assume that petroleum generation and stability are influenced by time, temperature, and kerogen composition alone. "Although Lewan limits his discussion to kerogen-derived sulfur radicals, there is no reason to believe that other sources of initiating radicals are not important," he says. "Now that it has been demonstrated that sulfur species play a critical role in regulating the stability of hydrocarbons at elevated temperatures, it would be wise to incorporate these effects into predictive models."

Michael Freemantle

Inventories-to-shipments ratio soars in November

The inventories-to-shipments ratio for chemicals jumped dramatically in November as shipments fell and inventories increased. According to the latest seasonally adjusted data from the Commerce Department, the ratio for chemicals and allied products increased to 1.37 in November, up from an upward revised 1.34 in October and from a good 1.24 in November 1996. Shipments fell 1.1% from the previous month, but they rose 6.0% from the same month the year before. Inventories, however, rose 1.2% from October and were up a huge 12.6% from November 1996. For industrial chemicals, the picture was the same, with the ratio increasing to 1.26 from 1.24 in October and from 1.22 in November 1996. Again, shipments declined, 0.6% from October, but were up 2.3% from November a year earlier. Inventories rose 1.4% in November on a month-to-month basis and swelled 5.5% when compared with year-earlier figures. This is the second straight monthly increase for the ratio both for chemicals and allied products and for industrial chemicals. November marked the seventh straight month of annual increases in the ratio for chemicals and allied products, and the industrial chemicals ratio has been rising when compared with year-earlier data for five out of six months.◀



Dynamite plant explosions kill at least three

Two powerful explosions at Sierra Chemical, Sparks, Nev., left at least three workers dead and sent at least nine people to the hospital, some with critical injuries, according to a Washoe County, Nev., spokesman. At C&EN press time, a Sierra spokesman would confirm only that four people were missing after the blasts and that operations there had ceased. Sierra Chemical makes explosives and industrial chemicals and operates four facilities, two in California and two in Nevada. The Sparks facility, near Reno, employs about 30 to 35 people, the company says, and is the only Sierra facility that makes explosives—mostly dynamite—for use in mining and weapons. Although the cause of the explosions has not been determined, the company spokesman says the destroyed buildings both contained explosive chemicals pentaerythritol tetranitrate and TNT. Investigations under way at the site involve officials from the Environmental Protection Agency and the Bureau of Alcohol, Tobacco & Firearms.◀

BP Chemicals to buy styrenics business from Hüls

BP Chemicals will buy Styrenix Kunststoffe, the styrene plastics business owned by Germany's Hüls, for more than $200 million. The purchase, which will make BP Chemicals one of Europe's largest producers of styrenics, will give BP two Hüls sites, in Marl, Germany, and Trelleborg, Sweden. BP already makes styrene compounds in plants near Lille, France, and in Wales. It plans to expand its Lille plants. Annual capacities involved in Marl are 380,000 metric tons per year of styrene, 420,000 metric tons of ethylbenzene, 180,000 metric tons of polystyrene, 75,000 metric tons of expandable polystyrene, and 250,000 metric tons of cumene; Trelleborg has capacity for 70,000 metric tons of polystyrene.◀

Potash Corp. to acquire Potacan

Potash Corp. of Saskatchewan (PCS), Saskatoon, Saskatchewan, has agreed to purchase Potash Co. of Canada (Potacan) from Kali & Salz Beteiligungs of Germany and Entreprise Miniére et Chimique of France. Financial details have not been disclosed. In October, Potacan gave up on its battle with flooding in its New Brunswick potash mine, just down the road from a PCS mine. PCS, which has converted a flooded mine into a usable solution mine, says it will consider converting the Potacan mine. Meantime, PCS says it will use Potacan's Clover Hill, New Brunswick, mill to upgrade potash from PCS's Saskatchewan mines for shipment to eastern Canada and the U.S. PCS says it may expand production of potash ore at its Sussex mine; the ore would also be processed at the Potacan mill. The companies expect to complete the sale early this year. Potacan's potash capacity is estimated at 1.3 million metric tons per year. Last year, PCS withdrew its bid to purchase Kali & Salz after European regulators refused to approve the sale.◀

DuPont undertakes more restructuring

DuPont has outlined intentions to restructure the support functions of its global chemicals and specialties businesses that may include layoffs of corporate personnel. A plan—to be developed in the first quarter and set into action in the second quarter—will redeploy employees who formerly worked in the centralized corporate functions such as engineering, legal counsel, and information technology into DuPont's various chemicals and specialties business units. The restructuring comes as DuPont attempts to assimilate the $6 billion in businesses that it has recently acquired. The effect of the redeployment will be to shrink the company's corporate bureaucracy, thus producing cost savings.◀

Shell to build phenol plant

Shell Chemical will build a new phenol facility at its Deer Park, Texas, site. The unit will provide an additional 500 million lb of phenol and 300 million lb of acetone, increasing Shell's total annual production more than 70%. Construction will begin next month, with completion expected in the second half of 1999. Financial details have not been disclosed. Deer Park is the only U.S. phenol production site for Shell Chemical, providing product primarily for domestic use.◀

Millennium completes buy of Rhône-Poulenc TiO_2 business

Millennium Chemicals has completed the purchase of Thann et Mulhouse, the titanium dioxide and specialty chemicals subsidiary of France's Rhône-Poulenc, for $185 million in cash. The purchase price includes the assumption of debt associated with Thann et Mulhouse. As part of the deal—first proposed in October (C&EN, Oct. 27, 1997, page 13)—Millennium receives TiO_2 production facilities in Le Havre and Thann, France. The plants have annual TiO_2 capacity of 33,000 metric tons and 105,000 metric tons, respectively. They will be integrated into Millennium Inorganic Chemicals, which has regional headquarters in Stallingborough, England. The Thann plant also produces titanium tetrachloride, zirconium oxide, chlorosulfate, and other specialty chemicals. The addition of Thann et Mulhouse positions Millennium, based in Iselin, N.J., as the world's second largest TiO_2 producer, behind DuPont. Its total annual TiO_2 capacity is now 611,000 metric tons, says Millennium.◀

Monsanto makes deal to improve Roundup

Monsanto has signed a research agreement with Flamel Technologies, Lyon, France, to develop an enhanced formulation of its herbicide Roundup. Utilizing Flamel's nanoencapsulation technology, known as Agsome Agrochemical Delivery System, the companies plan to increase the agrochemical efficiency of the active ingredients in Roundup. This agreement replaces an August 1996 version and expands Monsanto's rights to use the encapsulation technology in other crop protection products. It also permits Flamel to use its technology in areas other than agrochemicals. "We believe the successful application of this technology to Monsanto agricultural products will create a unique market opportunity for both Monsanto and Flamel," says Gerard Soula, chief executive officer of Flamel.◀

Courtaulds, Lenzing settle patent dispute

Britain's Courtaulds and Austria's Lenzing have settled their dispute over patent coverage for lyocell cellulosic fibers. Under the terms of the settlement, each company will cross-license to the other, on a royalty-free basis, all lyocell-related patents. Both companies can therefore produce and sell lyocell staple fiber anywhere in the world, without restriction. The lyocell technology, for producing cellulosic fibers using a solvent spinning technique, is key to Courtaulds' Tencel fibers, which it makes in two plants in Mobile, Ala. Courtaulds also has a plant under construction in the U.K. Lenzing lyocell fibers have been commercially available since July 1997, with production in Heiligenkreuz, Austria.◀

ICI opens new year with more reshuffling

British chemicals firm ICI is continuing its efforts to transform itself into a specialties company, with continued portfolio deals. It opened the year with the sale of its thermoplastic urethanes plant in western England to BF Goodrich, through a partnership with Goodrich to make the compounds for footwear. That transaction was announced four days after ICI completed the sale to DuPont of its polyester polymer and intermediates business in the U.S. and the U.K. as well as its 70% stake in a Taiwanese joint venture to make the polyester intermediate purified terephthalic acid. The sale price to DuPont was \$1.4 billion in cash and assumed liabilities; it was part of a \$3 billion agreement that also included ICI's sale to DuPont of its titanium dioxide business outside North America and its polyester films businesses. In the same week, ICI wrapped up a deal involving the sale of its share in a South African-based AECI Explosives joint venture to partner AECI, Johannesburg. That followed the completion of ICI's sale of its U.K. fertilizer business to Sioux City, Iowa-based Terra Industries, after approval by competition authorities in Europe.◀

Moroccan phosphates plant one step closer to fruition

Interim approval has been given by the directors of Belgium's Société Chimique Prayon-Rupel for the construction of a sodium tripolyphosphate plant in Morocco announced last June. Prayon will be in a venture with Office Chérifien des Phosphates, the Moroccan-government-owned phosphates company. The joint venture will use purified phosphoric acid as a raw material for the plant, which will have initial capacity of 50,000 metric tons per year. Construction is expected to start in April. The plant is being designed to allow for a future doubling of capacity. The two partners are already shareholders in a joint venture, Euro Maroc Phosphore, with German fine chemicals company Budenheim, to make purified phosphoric acid in Jorf Lasfar, Morocco. The Jorf Lasfar plant has just come onstream, the partners say, and will provide feedstock for the new plant.◀

Advanced polymers for China from new venture

Montell, of Amsterdam, and Taiwan Polypropylene Co. have agreed to form a joint-venture company, Montell-TPP China Advanced Polymers Co. (MTC Advanced Polymers), in Hong Kong for making polyolefin-based advanced materials for the Chinese market. The new company plans to build a plant—with initial capacity of 7,000 metric tons per year—and a technical center located in facilities previously used as a technical center by Montell. Start-up is expected this autumn. Meanwhile, the company will begin marketing materials sourced from the two parent firms.◀

UV-curing resins venture set for Japan

Tokyo-based JSR and the resins division of Dutch chemicals producer DSM will build a plant to make high-performance ultraviolet-curing materials for their 50-50 joint venture, Japan Fine Coatings. The plant will be located in Nihari-mura, Japan, have a capacity of more than 3,000 metric tons per year, and cost roughly \$30 million. It is scheduled for completion in 1999. Japan Fine Coatings makes UV-curing materials for protective coatings and inks as well as matrix materials for optical glass fibers and cables.◀

Business Roundup

- Regulatory authorities have stalled Hercules' \$1.8 billion bid for Britain's Allied Colloids. The Wilmington, Del.-based company has extended its offer to Jan. 14.
- ChemFirst, Jackson, Miss., has completed the acquisition of Switzerland-based Clariant's acylation derivatives business.
- PPG Industries has completed the acquisition of Sipsy Chimie Fine of Avrille, France, from the Jouveinal subsidiary of Warner-Lambert.
- Dow Chemical's wholly owned DowElanco subsidiary has adopted the name Dow AgroSciences. Dow Chemical acquired Eli Lilly's 40% stake in what was then a joint venture last July for \$900 million.◀

Early headquarters on Washington Square (1928), today's home office on Independence Mall in Philadelphia

U.S. issues charges in tobacco industry probe . . .

In the Justice Department's first criminal action in its three-year investigation of the tobacco industry, the department has charged DNA Plant Technology (DNAP) with conspiring with a tobacco company to develop a genetically altered tobacco plant with a high nicotine content. DNAP, of Oakland, Calif., has agreed to plead guilty to violating the tobacco seed export law and faces a maximum fine of $200,000. The law was repealed in 1991, but the company's violations occurred before the repeal. In its filing in the federal district court in Washington, D.C., the Justice Department also cited an anonymous tobacco company as an unindicted coconspirator. Brown & Williamson, a unit of B.A.T. Industries (U.K.), has admitted to being that company. The Justice Department contends that Brown & Williamson's intent was to use the new tobacco plant to manipulate the content of nicotine in cigarettes. The tobacco company denies this charge. According to court papers, DNAP sent genetically altered seeds to Brown & Williamson's test site in Brazil without obtaining proper export permits. Three years ago, Brown & Williamson acknowledged a program to develop in Brazil and other countries a genetically altered plant, which it code-named Y-1. This plant contained 6% nicotine—twice the content of normal plants—and could not under law be grown in the U.S. The company contends it used the altered plant to ensure standardized nicotine levels in the blended tobacco in some of its cigarette brands in 1993 and 1994.◀

. . . and NRC wants FDA's ability to regulate tobacco strengthened

The National Cancer Policy Board of the Institute of Medicine and the National Research Council has issued its first white paper on tobacco control because smoking is the single largest cause of cancer deaths in the U.S. In this policy statement, the board says the easiest and most direct way of cutting smoking is to increase the cost to smokers by tacking on a hefty tax—at least $2.00 per pack of cigarettes. Revenues generated could be used to support the government's tobacco control measures and its research efforts. Noting the legal uncertainties in FDA's ability to regulate the addictive agent—nicotine—in tobacco products, the board calls on Congress to clarify and strengthen the agency's regulatory armament. Although it did not dictate the outline of such legislation, the board says, "FDA's authority must be broad enough to allow it to protect the public health on the basis of scientific knowledge as it accumulates." Also, the board says the U.S. should support international efforts to control tobacco use by not implementing trade policies that would undermine those efforts.◀

EPA sued over compliance monitoring

The Natural Resources Defense Council has sued EPA in hopes of overturning a final rule that establishes monitoring requirements for some major sources of air pollution. The compliance assurance monitoring rule, which was published last October, applies only to sources that use control equipment to meet their emissions limits. It requires that sources monitor the operation of their control equipment—not that they monitor actual emissions from a facility. NRDC says the rule does not give citizens any way of determining a source's actual emissions and does not meet the monitoring goals set by Congress in the Clean Air Act. NRDC is pushing for regulations that would require continuous emissions monitoring.◀

Chemical safety board sets up in Washington

The Chemical Safety & Hazard Investigation Board (CSHIB), still too new and small to cut much of a profile, began moving into its new quarters in Washington, D.C., last week. The board was created by Congress in 1990, but the Bush Administration decided it wasn't needed and appointed no one to it. President Clinton actually named five members, three of whom were confirmed, and then he refused to fund it. Clinton signed the first budget for CSHIB for this year—$4 million (C&EN, Nov. 10, 1997, page 20). The board's chairman is Paul L. Hill, president of the National Institute of Chemical Studies in Charleston, W.Va. CSHIB's new address is 1201 Pennsylvania Ave., N.W. (20036); phone (202) 737-7270, fax (202) 661-4699, and e-mail: poje@csb.gov. First on Hill's docket, according to board member Gerald Poje, is assembling a staff of 20 to begin setting protocols for investigations. The third confirmed board member is Devra Lee Davis of the World Resources Institute.◀

Government action sought to protect oceans

More than 1,600 scientists from 65 countries have issued a joint statement, "Troubled Waters: A Call for Action." It explains how humankind is harming the sea's species and ecosystems and calls upon the public and political leaders to take immediate action to prevent further irreversible damage. The scientists call on governments to increase the number of protected marine areas so that 20% of exclusive economic zones and the high seas are protected from threats by 2020, to minimize pollution discharged at sea, and to provide sufficient resources for marine conservation biology research. Rep. Curt Weldon (R-Pa.) says the National Oceanographic Partnership Act of 1996 is helping coordinate U.S. investment in oceanographic research.◀

Government Roundup

- NSF's new deputy director in all likelihood will be ecologist Rita R. Colwell, currently president of the Biotechnology Institute at the University of Maryland, College Park. Official Washington is confirming she is the choice, although President Clinton has not yet submitted her name to Congress for nomination.
- Valdas K. Adamkus, 71, who served 27 years with EPA and was regional administrator of EPA Region V out of Chicago from 1981 until his retirement in June 1997, has been elected president of Lithuania.
- EPA has released its first survey of the quality of river and estuary sediments. The study examined contaminant data on 1,363 of the 2,111 watersheds in the U.S. It finds that just 7% of sediments are sufficiently contaminated to pose potential risks to people who eat fish from those waters.◀

Laser method makes thin semiconductor nanowires

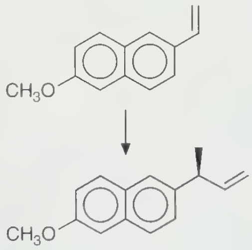
To observe quantum effects in crystalline semiconductor nanowires, scientists have to make these one-dimensional structures exquisitely thin—10 nm or less across. That has proven to be very difficult. Now, graduate student Alfredo M. Morales and chemistry professor Charles M. Lieber of Harvard University have described a method for making single-crystal silicon and germanium nanowires with diameters as small as 6 and 3 nm, respectively, and lengths greater than 1 µm [*Science*, **279**, 208 (1998)]. The method combines two well-known techniques—laser ablation and vapor-liquid-solid growth—in an "ingenious" fashion, says one reviewer. To make silicon nanowires, the Harvard researchers use a laser to vaporize a silicon target containing a small amount of a catalyst such as iron, nickel, or gold. The target is inside a furnace whose temperature is controlled so that the vaporized atoms will condense into liquid silicon-catalyst nanoclusters. As more silicon vapor condenses on these nanodroplets, a silicon nanowire grows out of each droplet as an inert gas stream wafts it through the furnace toward a cold finger, where growth stops. Lieber says the method, which also has yielded silicon carbide nanowires, promises to be a general route to crystalline nanowires of various materials.◀

Warm up the forests, lose the CO_2

Boreal forests, which contain some of the largest reservoirs of carbon in Earth's biosphere, could release significant amounts of carbon dioxide from their soils into the atmosphere if the global climate continues to warm, a scientific team reports. Michael L. Goulden, until recently a research associate in the earth and planetary sciences department at Harvard University, and colleagues have found that the thawing of the often frozen soils of these northern forests leads to an increased efflux of carbon dioxide. In a black spruce forest in Manitoba between 1994 and 1997, they tracked this effect by measuring CO_2 fluxes in the air and ground using various techniques. They were able to show that during the thawing periods, decomposition of organic matter increased 10-fold [*Science*, **279**, 214 (1998)]. "Moderate increases in temperature that increase soil thaw may therefore stimulate decomposition and result in a significant efflux of CO_2," Goulden says.◀

High-yield asymmetric addition of ethylene to aromatic olefins

Careful choice of catalyst has led chemists at Ohio State University, Columbus, to greatly improve the hydrovinylation reaction in which ethylene is added to vinyl arenes. Chemistry professor T. V. (Babu) RajanBabu and coworkers find the reaction proceeds with "unprecedented chemical yield and selectivity" when they form the catalyst using a combination of allyl nickel bromide, a weakly coordinating counteranion such as triflate or tetraarylborate, and a monophosphine such as triphenylphosphine. Unlike some other reported procedures that require high pressures of ethylene, the Ohio State method needs only 1 atm.



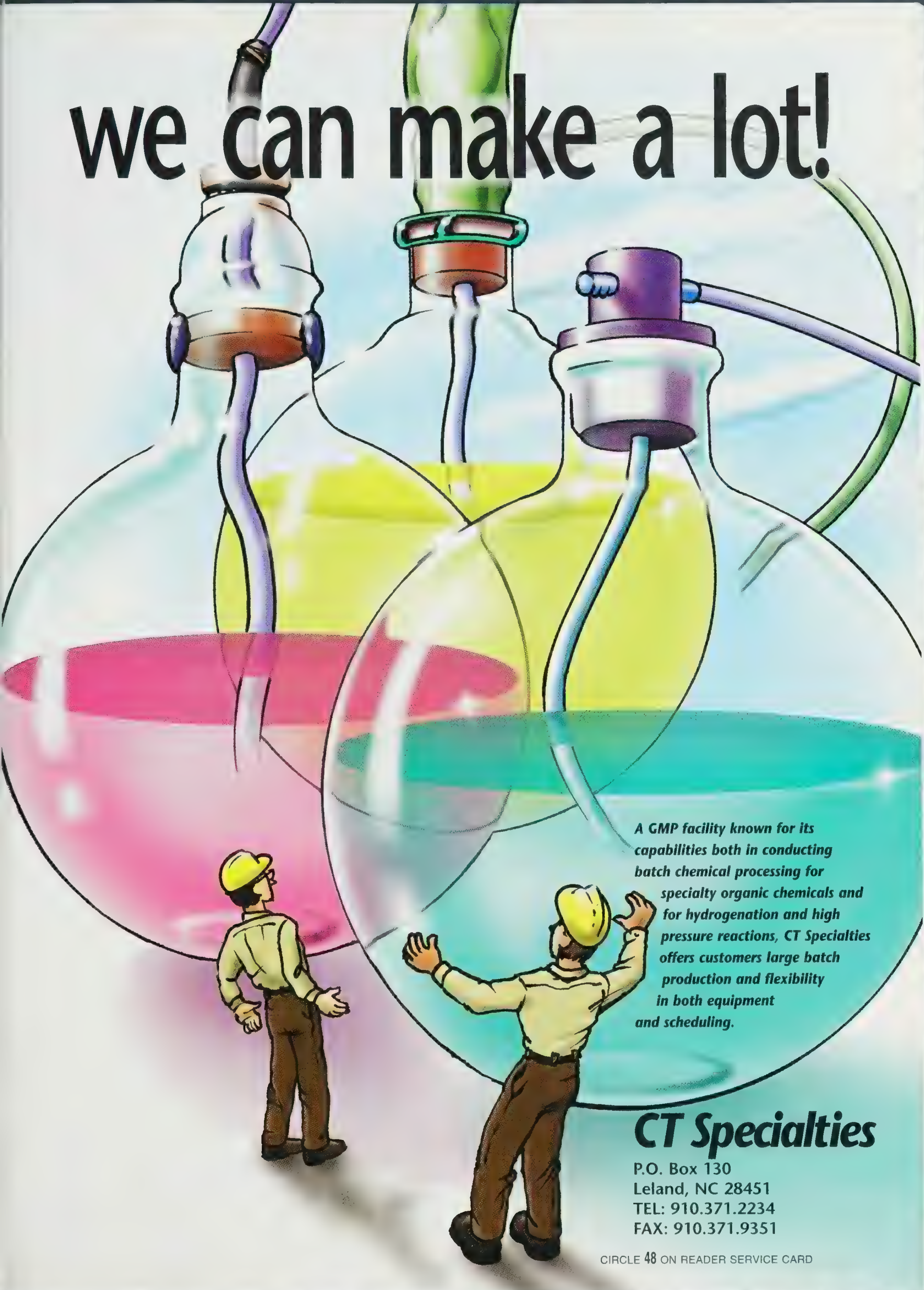
The protocol can be adapted for asymmetric syntheses by using a chiral monophosphine with an alkoxy ligand that can stabilize the cationic nickel species thought to be intermediates in the reaction. For example, the transformation of 2-methoxy-6-vinylnaphthalene to the asymmetric hydrovinylation product (reaction shown above) proceeds in nearly quantitative yield and with an enantiomeric excess of 80%. The Ohio State communication was posted Jan. 3 on the *Journal of the American Chemical Society*'s web edition (pubs.acs.org/journals/jacsat), as part of ACS's new "Articles ASAP" (As Soon As Publishable) service. ASAP articles—accessible only to journal web edition subscribers—have gone through peer review and editing, but haven't yet been printed.◀

Pile it on for better weighing

An unusual weighing procedure can boost precision and accuracy significantly and may be useful in quality-control applications, according to researchers Philip B. Henderson, Thomas J. Bzik, and J. Peter Hobbs at Air Products & Chemicals, Allentown, Pa. [*Anal. Chem.*, **70**, 58 (1998)]. They developed the method using techniques more commonly used to find the most efficient way to obtain information from a collection of experiments involving several variables. The weighing technique works when six or more items are to be weighed. An example in the article concerns solvent weight loss from eight sealed plastic bottles over several weeks. Rather than weighing the bottles one at a time, eight different subsets of the bottles were grouped on the balance. Weights for the individual bottles were then worked out mathematically. The researchers found that the procedure removed scale bias and increased precision 25% in this particular case as compared with conventional techniques. They note that "once an operator becomes familiar with the weighing scheme . . . this procedure takes no more time to complete than individual weighings."◀

New molecules key to how dying cells destroy DNA

A team of Japanese geneticists has identified two molecules critical to disassembling the genes of mammalian cells in the process of orderly cell death called apoptosis. Shigekazu Nagata and colleagues at Osaka University Medical School and Osaka Bioscience Institute have identified and cloned a previously unknown enzyme that degrades DNA in the nucleus of mammalian cells [*Nature*, **391**, 43 and 96 (1998)]. They call the enzyme caspase-activated deoxyribonuclease (CAD). This protein appears to be widely present in cells but is bound to a second newfound protein that inhibits it. The researchers call the inhibitor ICAD. "CAD exists as an inactive complex with ICAD in living cells," they write. "Caspases activated by apoptotic signals cleave ICAD to release CAD, which then enters the nucleus to degrade chromosomal DNA." ICAD appears to act as a chaperone during the synthesis of CAD, helping to ensure that it folds correctly and doesn't improperly associate with other polypeptides. Unlike many other molecular chaperones, however, ICAD seems to be specific to this one enzyme and to remain bound to it, keeping the protein in check until it's needed.◀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C&EN: 75 Years Of Great Chemistry

As chemical enterprise has expanded, 'News Edition' has evolved from ACS house publication to global newsmagazine

David J. Hanson
C&EN Washington

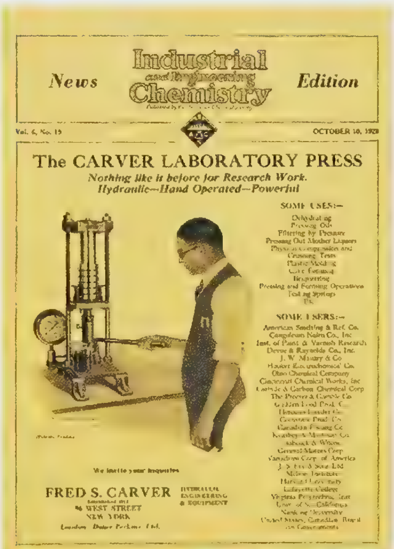
The American Chemical Society had been in existence 46 years by the end of 1922 and was an integral part of a fast-growing chemical enterprise. The *Journal of Industrial & Engineering Chemistry,* a monthly journal published by the society since 1909, then served as the source of chemical news and society information for ACS members, informing them of new processes, events abroad, and activities of their fellow members.

But the pace of developments in the chemical world following World War I was quickening, and it became evident that the monthly *I&EC* was too slow to pass along timely news and information. So *I&EC* Editor Harrison E. Howe convinced the ACS Board of Directors that a more frequent and separate news publication was warranted.

Thus, on Jan. 10, 1923, ACS published the first issue of *Industrial & Engineering Chemistry News Edition.* "We offer for your approval the News Edition," wrote Howe in that issue. Its purpose was to "print personal items, a large range of industrial development information, and accounts of activities of local sections." It would also carry features on federal and state legislation, news of foreign events, announcements of new trade publications, and a host of similar topics. "We believe the News Edition will serve a useful purpose in knitting more closely together the various interests in the society membership," he concluded.

The News Edition started publication with a staff of four, and was supplemented with information from the ACS News Service and the cooperation of "staff correspondents." The same four people were the editorial staff for *I&EC.* The ACS Board had approved the creation of the twice-monthly publication at its Nov. 24, 1922, meeting, and, interestingly, the society's members were never officially informed of the change. In fact, *I&EC* regular editions continued to carry some news pages and editorials.

The News Edition was published on the 10th and 20th of each month, and, as was the custom at the time, it was included with all the other ACS publications (*I&EC,* the *Journal of the American Chemical Society,* and *Chemical Abstracts*) as part of the ACS dues package. Each issue was 12 pages, including ads. In 1925, the publication was expanded to 16 pages. That same year, some international news was added, usually in the form of "letters" from correspondents from various nations describing the chemical news from that country. Crossword puzzles with chemical solutions—very popular during that time—made frequent appearances in the News Edition.



1928

From the start, the News Edition was printed in, and mailed from, Easton, Pa., by Eschenbach Printing Co., which had been printing all the ACS publications since 1893. In 1926, the company was renamed Mack Printing Co., the name it bears today, after Harvey F. Mack, who had joined the firm when it was Chemical Publishing Co. in 1900 and who eventually became part owner.

The publication changed little in the 1920s and early 1930s, slowly adding pages and staff. But in 1934, ACS decided to cut back on the publications package sent to all members, leaving the News Edition as the only ACS publication received by every member as part of the dues package. On Jan. 7, 1938, the board of directors voted to make the News Edition the "official organ" of the society, and, in 1940, the publication's dates were changed to the 10th and 25th of each month.

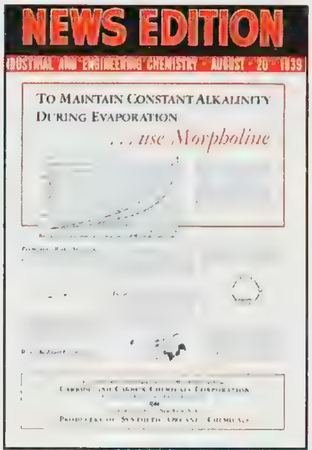
It was also in 1938 that the editorial content began to change. For the first time, occasional short articles of a more technical nature, which had appeared only in the monthly I&EC, were published in the News Edition, supplementing the strictly industrial and academic news features, ACS information, and market reports that were the staple of the magazine. Soon, other items were added, such as new developments in industry, chemistry, and economics, and the importance of the chemical enterprise to the U.S. defense program.

In 1940, the magazine published for the first time a list of university departments of chemistry that, in the judgment of the ACS Committee on Accrediting Education Institutions, offered bachelor's degrees fulfilling ACS requirements for professional training of chemists.

The expansion of coverage in the

1923-43

Howe



1939

Murphy

1943-55

magazine and separate mailing to all ACS members led to consideration of a name change for the publication, and, on Jan. 10, 1942, the magazine was first published as *Chemical & Engineering News*.

Over those first 20 years, despite the efforts to increase the editorial scope of the magazine, it could still be fairly described as a house organ for the society. But by the early 1940s, C&EN had become the largest circulation publication serving the chemical profession and industry. In fact, its circulation had more than doubled in just eight years to more than 30,000 by 1943. The number of pages expanded during this time from about 16 pages per issue to more than 40 pages, and included some longer feature stories.

In response to this growth, ACS moved to expand C&EN's editorial mission to include more timely news about the chemical industry and science, in addition to ACS proceedings. The slogan "Newsmagazine of the Chemical World" was added to the masthead, and in 1943, for the first time, a contents page was added.

February 1943 marked the end of an era for ACS and its newsmagazine. Howe, founder and editor for the magazine's entire 20-year history, died suddenly. He had also been responsible for splitting off the I&EC Analytical Edition, which eventually became *Analytical Chemistry* in 1948. His efforts had a long-lasting impact on the society's publishing history.

Howe was succeeded as C&EN editor by Walter J. Murphy, who, in addition to having chemical research and industrial experience, had been an editor of another chemical-oriented news publication—McGraw-Hill's *Chemical Industries*, which later was renamed *Chemical Week*. Murphy was offered the position by ACS Secretary Charles Lathrop Parsons, and before Murphy agreed, it was arranged that the editor of C&EN would report directly to the society's board of directors, not to the ACS secretary as Howe had done.

Murphy decided the chemical profession was ready to support a larger, more professional news publication and used his experience to set up a more effective news-gathering organization. Until then, the magazine had only a small staff centered in Washington, D.C., and a single reporter in New York City. Starting in January 1945, Murphy opened a string of field offices and in 18 months had established C&EN news bureaus in Chicago, Houston, and San Francisco. This growing news strength convinced ACS to expand C&EN from a bimonthly to a weekly magazine at the beginning of 1947. The change actually was approved in April 1944, but war shortages in paper and personnel made it impossible to effect the change until nearly three years later.

Editorial improvements in the magazine accelerated throughout the 1940s. A back page column called "News Scripts" was added in July 1943. The first editorials appeared in C&EN in October 1945. These were seen by Murphy as a way to get the attention of chemists and chemical engineers on matters of importance to them and their industry. C&EN also began publishing symposia and annual reviews of the chemical industry, including, of course, stories on the chemical industry expansions that occurred during World War II.

Murphy wrote that, starting with the weekly magazine in 1947, "principal efforts were directed toward increasing the scope and timeliness of the material presented." For instance, when the news of the first use of the atomic bomb was announced, Murphy organized a major effort by the staff and produced an eight-page special insert for the Aug. 10, 1945, issue called "Harnessing of Nuclear Energy," which as far as is known, scooped every other technical and trade publication to get the nuclear power story to its readers. Through this period, C&EN's editorial views supported civilian control of nuclear energy.

Further boosting the magazine's professional appeal, C&EN published in its Feb. 17, 1947, issue a special insert, the 60-page "Hancock Report on Organization of the American Chemical Society," compiled by John M. Hancock, who authored several important manpower and postwar reports for various organizations. This report was a major study of the policies and organization of ACS, including opinion surveys of ACS members.

Murphy initiated another innovation to get timely news into the magazine, the C&EN Concentrates page, first published in the May 23, 1949, issue and printed as con**CEN**trates to incorporate the magazine's initials.

Another major change instituted by Murphy was in C&EN's appearance. Until 1946, all of the covers of the magazine were advertisements for chemical suppliers and companies (as were the covers of I&EC). But a series of articles on major personalities in the profession began in the Jan. 10, 1946, issue, the cover of which was a portrait of ACS Secretary

1947

1956–62

Kenyon

Photo by Cliff Bond

1962–69

Bixler

Parsons, who was retiring after 39 years of service to ACS. Similar portraits and drawings of eminent chemists and chemical leaders became standard on the cover for more than 10 years. In late 1949, photos replaced the drawings, and gradually other photos appeared with the chemists. But it wasn't until about 1955 that a C&EN cover had no chemist on it at all. An early example is the Nov. 28, 1955, cover highlighting cancer chemotherapy. It featured a photo of a partially filled Erlenmeyer flask.

Murphy's expansion of the magazine took a major leap in 1950 when he assigned Richard Kenyon from the Chicago field office to open a new C&EN field office in London. Kenyon's job was to report on the recovery of the European chemical industry following the war. The success of this international coverage for C&EN led to further expansion of overseas reporting in Europe and Asia in the 1960s.

By 1950, the magazine was printing more than 2,700 editorial pages yearly (compared with 324 pages in 1923), and that included a 176-page issue on the Diamond Jubilee of ACS. Among other changes during this era, the magazine dropped continuous pagination throughout the year and started using department logos on news pages. In 1955, the publication was entirely remodeled, including putting the news section—the Chemical World This Week—at the front, and initiating the C&EN career supplement in 1957. The news aspect of C&EN was reemphasized further when the Sept. 23, 1957, issue opened with a news lead instead of a feature or special report for the first time, with a two-page story on record attendance at the ACS meeting in New York City.

In 1955, Murphy was promoted to ACS editorial director for the applied journals, and in June 1956, he named Kenyon, who had become editor of the ACS publication *Journal of Agricultural & Food Chemistry,* as the new editor of C&EN. Kenyon was subsequently appointed editorial director of ACS applied publications after Murphy's untimely death at the end of 1959.

Kenyon took the changes Murphy had made in C&EN and magnified them. He seemed to have a vision of C&EN as a truly global newsmagazine. By 1961, Kenyon had built up the magazine with a number of changes, including revising the makeup and typography, new pages for research and for government concentrates, and moving the Letters to the Editor department up front. The staff of reporters continued to grow, and new field offices were set up in Philadelphia (June 1961), Frankfurt (November 1961), and Cleveland and Los Angeles (December 1961). As the magazine expanded, future offices were contemplated for Boston, Montreal, and even Buenos Aires, but these three never materialized.

During this period of growth, Mack Printing also contributed to the success of ACS's publications program, and the two organizations maintained a close relationship with respect to modernization. For example, Mack's first web-fed rotary letterpress was installed in 1957 to handle the printing of C&EN. The faster press cut two days off the magazine's production time.

In August 1962, Kenyon was promoted to director of publications for applied journals, and he had to give up the editorship of C&EN. He was succeeded by Gordon Bixler, then the managing editor and a former chemical researcher who had been with the magazine since 1952. Bixler arrived at the helm at a time of rising revenues and rising editorial pages for the magazine, and he shortly began to reshape the magazine. By 1964, Bixler had reinvigorated the features program, with a reemphasis on detailed articles written by eminent scientists in the field and designed to bring readers the background and state-of-the-art science of interesting issues.

Of particular interest were three special reports written by C&EN staffers that included special commissioned art as illustrations. Watercolor artist Dong Kingman painted original pictures for a feature on the Earth, and Frank Mullins created illustrations for articles on oceanography and on the atmosphere. These three features were combined and sold as a reprint.

The technical production of the magazine moved ahead under Bixler's leadership as well. Full-color illustrations made their first appearance in C&EN articles in the early 1960s, made possible to some extent by the increased demand for color printing by C&EN advertisers. In 1964, the magazine introduced a Teletypesetter system for transmitting story copy from its Washington editorial office directly to Mack Printing. Using long-distance Teletype lines and coded punched paper tapes, the system fed into a Linotype hot-lead typesetting machine at Mack that set the type for each story. Before this, all editorial copy was typed (often from

1969–73

McCurdy

1970

1974–77

Plant

telegraph messages) and hand delivered to the printer, where it was set in type manually by typesetters.

Record levels of advertising from the chemical and allied products industry fed the C&EN expansion in the 1960s, leading to production of a record of nearly 3,100 editorial pages in 1966 and what was then a record $4 million in revenue. But 1966 was to be a high point for the magazine, and the next several years were to bring hardships for both C&EN and the chemical industry.

Beginning in 1967, advertising revenue began to slip as magazine production costs continued to rise. The chemical industry's financial problems stemmed from severe overcapacity, and subsequent lower profits led to drastic cutbacks in advertising. Editorial pages were trimmed each year to try to get the budget in balance, dropping to 2,900 pages in 1968 and 2,500 pages in 1969, but C&EN was falling into serious financial trouble. Bixler asked to be relieved as editor in early 1969, and was replaced by then-Managing Editor Patrick P. McCurdy.

McCurdy's job was unenviable. Faced with a badly deteriorating financial situation over which he had no control, he had to fight political and financial battles within ACS to try to maintain the magazine's credible journalistic content and its breadth. He pushed through a facelift for C&EN designed to bring it more of a look of national weekly newsmagazines and strove for more emphasis on news in the writing of department stories.

Still, McCurdy could not keep up the size of the publication in face of the poor advertising revenues. Editorial pages dropped steeply from 2,500 in 1970 to 1,980 in 1971, and to the lowest point of just more than 1,350 in 1972. The situation had sad consequences. By 1971, McCurdy was faced with a budget shortfall of $135,000 even after cutting the page budget by 400 pages. So in late 1971, faced with a choice of doing "irreparable harm to the core of the magazine," he made what he calls "the toughest decision of my life"—to cut staff. Six editors and two secretaries were laid off with three months' notice. Overall, the C&EN editorial staff dwindled between 1967 and 1973 from a high of nearly 50 to just 22 in 1973. Most of the far-flung field offices were closed as staff left or were brought back to Washington headquarters, eventually leaving just one-person operations in Chicago, Houston, New York, and London by 1976.

The situation forced ACS governance finally to do something about the deteriorating condition of C&EN. Many arguments were put forward about the future of the magazine, some that would have altered its fate forever. These included reverting back to a bimonthly newsmagazine, as it had been until 1947, or even just a monthly. There was also pressure to split the magazine into an ACS society house organ and a second magazine for general chemical news that financially would have to stand on its own.

One vocal faction of ACS members, perhaps responding to the mass firings of chemists that had come with the misfortunes of the chemical industry, pushed for C&EN to become the voice for "professionalism" in chemistry and to support the jobs of chemists. Others wanted C&EN to concentrate almost totally on coverage of science.

McCurdy held strongly to the idea of C&EN as a newsmagazine and convinced the society that C&EN's greatest value to ACS members was as a credible news source. A special committee was formed to consider the future of the magazine, and it concluded that C&EN was important as the one continuous contact between the society and its members. The magazine was called "the glue that holds the society together." It was retained as a weekly publication, with smaller staff and budget.

One decision to come out of this debate was the recognition that the society needed to provide C&EN with greater financial support. Since 1950, $3.00 of each member's dues had been allocated to C&EN, a sum that over the years covered very little of the magazine's actual costs. McCurdy successfully argued that, for the magazine's recovery, a larger allocation was needed. In April 1972, the ACS Council voted the first increase in 22 years, raising the C&EN allocation by $2.00 to reach $5.00 per member. By the end of the year, advertising revenues had stopped falling, and in 1973 subscription revenues increased 50%, putting C&EN back on a road of rebuilding. Although 1973 editorial pages still totaled only 1,380, at least the publication was no longer shrinking.

That year, the magazine published its 50th anniversary issue, on Jan. 15, that reviewed the status of chemistry and C&EN since 1923. The 100-page special issue included outlooks for the world of chemical science, industry, and education to the year 2000. Among the changes pre-

1977–95

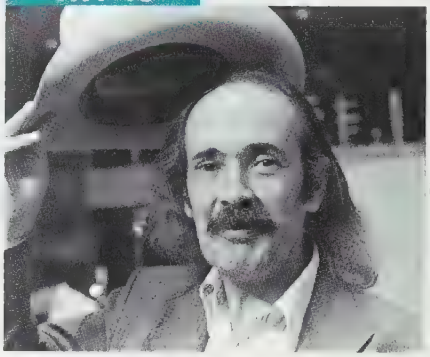

Heylin

Photo by Ernest Carpenter

1984

1993

dicted by a panel of industrial experts at that time was that the chemical enterprise would become more diverse and international in scope, that it would become a major factor in an environmental cleanup industry, and that the federal government would have to take the lead in developing new energy sources before the world ran out of natural gas and oil.

But just as the magazine seemed to be stabilizing, McCurdy resigned as editor in November 1973. He had, ironically, been offered the job of editor of *Chemical Week,* C&EN's main competition in the chemical news field, and the publication that Walter Murphy had left to head C&EN almost 25 years before.

In June 1974, Albert F. Plant was named editor of C&EN. Plant had been editor of *Industrial Research* magazine and brought a sense of news and journalism to C&EN that continued the vision of Bixler and McCurdy. Although Plant was editor only until 1977, he oversaw the beginning of the publication's recovery from near disaster.

A comprehensive reader survey during that period indicated ACS members wanted more feature material and increased coverage of science and technology in C&EN, and efforts to meet that demand shaped many of the changes in the magazine over the next several years. The technical features had, through the 1960s, been part of I&EC, but that journal also was cut drastically by advertising misfortunes, reduced drastically in size, and converted to three quarterly editions with no news, only scientific papers. So ACS members had no ready source of technically written review papers available by the early 1970s. The result was, by 1976, most of the editorial expansion of C&EN was in scientific features. Staff size increased slowly, and 17 major features were printed that year. Revenues also started to rise for the magazine, including another increase in the dues allocation from $5.00 to $8.00, allowing for increasing page budgets, which were up to nearly 1,800 again by 1976. That was also the year C&EN published a special edition for the ACS 100th anniversary. This hardbound issue dated April 6 included a review of the past 100 years of chemical science and the profession of chemistry as written by eminent chemists.

After only three years as editor, Plant was moved to a newly created position of C&EN publisher, and Michael Heylin was named C&EN editor. Heylin had joined C&EN in 1963 and had served as managing editor since 1973 under editors McCurdy and Plant. Heylin's vision of C&EN as the "magazine that had to be read" by everyone in the chemical profession helped it grow to become a major player in the chemical publications field.

Aside from occasional longer features, C&EN had been doing mostly shorter news stories, a result of its diminished page budget and staff from the early 1970s. The magazine had kept its core features and strove to maintain its strength as a journalistic publication as it recovered financially. When the kepone story broke in August 1975—the episode of egregious carelessness in making the pesticide that contaminated the town of Hopewell, Va., and the surrounding area—C&EN didn't have a mechanism for giving such a broad story the scope it deserved. So Heylin and staff developed the News Focus, a story shorter than the magazine's special features but one that would cover an issue quickly and journalistically in depth and from all sides.

The News Focus concept provided the opportunity for significant coverage to a number of chemical issues, and its use increased substantially throughout the early 1980s. Steadily rising editorial page budgets fed this surge in longer stories, which reached a peak in 1984 when the staff produced 18 News Focus articles and nine Special Reports. Outside scientists wrote another eight special features, bringing the number of major articles to 35 that year. The year also marked an advertising and editorial change that still affects the magazine today.

The first so-called Product Reports were published in 1984. These News Focus-length features were staff written and researched, each covering a well-defined segment of the chemical industry—for example, paints and coatings, rubber, and pharmaceuticals. But they were scheduled far enough in advance that C&EN could attract significant advertising from that industrial sector, improving the magazine's revenue base. These articles have proven very successful, and issues of C&EN that feature these articles today are among the most heavily advertised of the year.

A high point for the magazine in 1984 was the awarding to Senior Editor Lois R. Ember of the Science-in-Society Journalism Award from the National Association of Science Writers (NASW) for her Jan. 9, 1984, report entitled "Yellow Rain." NASW judges said the story provided a "tough,

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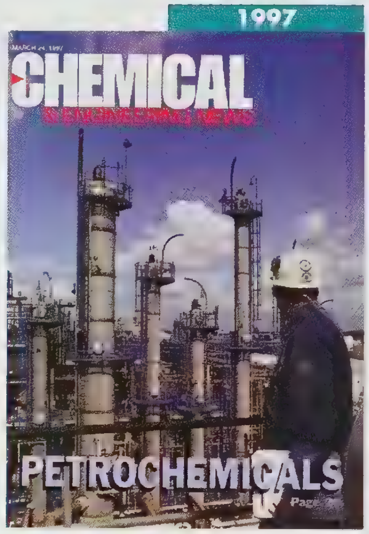
CIRCLE 89 ON READER SERVICE CARD

Photo by Ernest Carpenter

Jacobs



painstakingly researched, and unbiased look" at evidence purporting to U.S. claims that the Soviet Union was using toxin weapons in Afghanistan and Southeast Asia. In 1985, Ember also won the prestigious George Polk Award for special-interest reporting for the same report.

Another first for the magazine was the June 6, 1983, issue, when C&EN devoted the entire content to the subject of a single chemical: 2,3,7,8-tetrachloro-*p*-dibenzodioxin. This compound, usually called just dioxin, was the focus of an enormous controversy because of its presence as a contaminant in the herbicide agent orange used in the Vietnam War, and its alleged responsibility for illness in Vietnam veterans. It had been found also contaminating many sites in the U.S. By using the talents of many staff members, C&EN provided the most comprehensive analysis of any magazine of the science, toxicology, health impact, history, regulatory outlook, and fears surrounding dioxin. A unique experiment for the magazine, it was extremely well received by readers.

A watershed event in the chemical world in 1984 highlighted how well this concept worked. When leaking methyl isocyanate killed thousands of people and maimed thousands more in the town of Bhopal, India, in the morning hours of Dec. 3, 1984, C&EN moved quickly to provide detailed information to its readers. C&EN Senior Editor Wil Lepkowski traveled to India to interview Indian leaders and Union Carbide officials to try to understand how the tragedy had occurred. The resulting feature on the political, industrial, and even social ramifications of the incident became a special issue of C&EN on Feb. 11, 1985.

Throughout his tenure, Heylin was able to slowly develop and expand C&EN staff and increase the magazine's reporting of science. Backed by generally steady advertising revenue increases and a 1977 change in the dues allocation from a fixed dollar amount to 23% of the dues, he was able to reopen and even expand some of the magazine's field offices. In July 1978, the West Coast field office was reopened. The New York office grew from two writers in 1977 to six in 1994 (and moved to New Jersey in July 1988). Total C&EN staff grew from just more than 20 to 37 in 1995, and the magazine's editorial page budget nearly doubled from its 1971 low to 2,400 editorial pages.

Along the way, the production and appearance of the magazine did not remain static. Abandoning the old Teletype tape method for transmitting copy to its printer, C&EN was an early user of telefacsimile machines in the early 1970s that sped the transfer of material to and from its field offices and to Mack Printing in Pennsylvania. For its part, Mack once again adopted new technology to speed up printing of the magazine, switching to web offset presses in 1971, and it began using computer photocomposition the next year. By the early 1980s, even faxes were considered slow and cumbersome for transmitting editorial material to the printer—and it all had to be retyped by Mack personnel to be readable on the computer scanner. The emerging computer industry provided new equipment to generate and edit copy, and to transmit articles via telephone lines to the printing company. A major redesign of the magazine in 1982, the first in a decade, enhanced the readability and appearance of C&EN and highlighted the increased use of color photographs and illustrations in the magazine.

Computer capabilities were expanded further in 1989 with the addition of computerized in-house typesetting that provided more overall control of the production of the magazine at ACS. More recently, increased use of computerized graphics and computer-scanned images has given the C&EN staff greater flexibility and opportunity to add vivid structures and chemical reactions to its pages.

Support from ACS also grew, when in 1993, an ACS bylaw change was passed that dropped the fixed 23% of dues allocation to C&EN and instead provided the magazine with the actual costs of printing and distributing the editorial (nonadvertising) portion of C&EN to its members and other subscribers.

In 1995, Heylin stepped down as editor, having served in that position for 18 years, a tenure exceeded only by the 20-year stint of the first editor, Harrison Howe. He has stayed on as editor-at-large. Over the years, Heylin says, the magazine has been buffeted by a variety of forces, a continual one being that C&EN should be a "mouthpiece" for chemists and the chemical profession and that one of its roles should be "to make chemists feel good about themselves." Instead, Heylin rebuilt C&EN, after its problems in the 1970s, back into a major news publication that "has to be read by those who make their living in the chemical professions."

His successor is the current editor,

Photo by Peter Cutts Photography/Cable Risdon

C&EN's current staff: (back row, from left) Stu Borman, Ann Thayer, William Schulz, Paige Morse, Ken Reese, James Krieger, Jean-François Tremblay, Marc Reisch, Ron Dagani, Phillip Payette, Stephen Stinson, Stephen Ritter, George Peaff, Mitch Jacoby; (middle row) Arlene Goldberg-Gist, Wil Lepkowski, Mairin Brennan, Janet Dodd, Julie Grisham, Patricia Oates, Robin Giroux, Bette Hileman, Jeff Johnson, Linda Raber, Michael Freemantle, Elizabeth Wilson, Diana Slade, Patricia Layman, Elisabeth Kirschner, Rita Johnson, Maureen Rouhi, Rebecca Rawls; (front row) David Hanson, Pamela Zurer, William Storck, Editor Madeleine Jacobs, Managing Editor Rudy Baum, Janice Long, Ernest Carpenter, and Michael Heylin. Not pictured: Robin Braverman, Lois Ember, Rachel Eskenazi, Linda Mattingly, and Sophie Wilkinson.

Madeleine Jacobs, who was a C&EN reporter from 1969 to 1972 and left C&EN for a writing and public affairs career with the federal government and then at the Smithsonian Institution. When she returned to the magazine in 1993, it was to revitalize the job of managing editor, a position Heylin had preferred not to have for the magazine for most of his term as editor. When Heylin stepped down, Jacobs was appointed editor in July 1995. Her goal was to create an environment where the C&EN staff "could do its finest work for its readers." The current staff of 39 full-time reporters and editors, Jacobs believes, is "the most technically astute and best qualified the magazine has ever had."

Jacobs also saw the need for a new overall design for C&EN. In her editorial introducing the refurbished product, she acknowledged that it had only been five years since the previous change, but, in the 1990s world of magazine publishing, "that's an eternity to be wearing the same suit of clothes." The redesign is meant to emphasize the magazine's focus on chemistry and sharpen the appearance so readers can quickly find the articles they want to read.

Jacobs' energetic style and outreach to the readers and advertisers of C&EN has been successful, as the publication continues to fare well both in readership surveys and in rising pages of advertising. Editorial pages, too, are growing, reaching nearly 2,500 pages in 1996, the most since 1969, and advertising revenues have reached an all-time high. And Jacobs, completing plans Heylin had begun earlier, expanded the C&EN field staff in summer 1995 by reinstituting a news bureau in Asia for the first time in more than 19 years with a full-time correspondent based in Hong Kong.

Another dramatic change for the magazine occurred at the end of 1997, when C&EN ended its 75-year relationship with Mack Printing. Beginning this month, C&EN is printed by Brown Printing Co. in Waseca, Minn., an experienced printer of weekly magazines and the firm expected to carry C&EN into the next century.

"To come up with a package each week that all of our readers, a very heterogeneous group, will want to pick up and read is a daunting challenge," Jacobs says. "We need to continue to be on top of stories, making sure that our readers see the stories that concern them first in C&EN and not somewhere else."

In the immediate future, Jacobs shares the vision begun by Murphy many years ago, and continued ever since, of making C&EN the global chemical newsmagazine. "We will be adding to our international readership in the next few years," she says, "because of the increasing globalization of the chemical enterprise."

The magazine will be attracting more international readership, both because of its global coverage and because of a new Internet version of the magazine to be launched later this year. It will be a product that will be more than just an electronic copy of C&EN, Jacobs says. It will be searchable on-line and provide access to databases and journal references. "It may be especially useful to readers outside the U.S. who will be able to get the news in a more timely fashion," Jacobs adds.

"The function of C&EN will become even more central to the missions of ACS, as the society strives to enlarge its membership," according to Jacobs. And this function goes back to the founding of C&EN by Harrison Howe as a publication to knit together a diverse membership. "It cuts across all the diverse disciplines of our science and binds everyone together, giving them all something in common to read each week," Jacobs says. "Now, and in the future, we will continue to be the glue that holds the membership together."◀

Chemistry Crystallizes Into Modern Science

The past 75 years have marked profound changes in the content, scope, and direction of the field

Stu Borman, Ron Dagani, Rebecca L. Rawls, and **Pamela S. Zurer**
C&EN Washington

Linus C. Pauling was a graduate student at California Institute of Technology in 1923, the year C&EN was born as the News Edition of *Industrial & Engineering Chemistry*. That year, he published his first paper, a report on the X-ray crystal structure of the mineral molybdenite in the *Journal of the American Chemical Society*.

At the University of Illinois, Roger Adams was exploring the use of platinum oxide as a catalyst to reduce organic compounds. He and his students meticulously characterized their products through melting and boiling points and elemental analysis and by making derivatives.

The same year, Thomas Midgley Jr. commissioned a safety study of tetraethyllead. Just two years earlier, the General Motors scientist had discovered that the compound was a superb antiknock agent in gasoline-powered auto engines.

The Svedberg, visiting at the University of Wisconsin during 1923, built the forerunner of the ultracentrifuge—an optical centrifuge to determine the particle size and size distribution of gold hydrosols. Joel H. Hildebrand, meanwhile, was investigating metallic solutions at the University of California, Berkeley.

Chemistry was a well-established science in 1923, with Ph.D.-granting departments at many universities in the U.S. The American Chemical Society, founded in 1876, was a going concern. In addition to *JACS*, many of the journals that are prominent publishers of chemical research today had been founded, including *Nature*, *Science*, and the *Proceedings of the National Academy of Sciences*.

A substantial chemical industry thrived in Europe, and a growing one existed in the U.S., where synthetic chemists fashioned products that included dyes, drugs, and explosives. But there were no condensation polymers, no drugs developed through rational design, and zeolites were just a curiosity of nature.

More fundamentally, chemists had only a sketchy notion of what constituted a chemical bond or how kinetics and thermodynamics drove molecules to react with one another along particular pathways. And although the concept of huge macromolecules had been proposed, most chemists didn't believe it. As one historian of science has put it, 70 to 80% of what is interesting in chemical science today was not understood to exist in 1923.

Since then, instruments and computers that can ease much of the work of analysis, modeling, and synthesis have greatly expanded the scope of questions that chemists can address. And they have dramatically increased the pace at which research frontiers advance. "A Ph.D. dissertation's amount of work in 1940 was, by 1960, an afternoon in the lab; the dissertation of 1960 was an afternoon in the lab in 1980s; and we keep repeating that," says chemical historian Arnold Thackray, president of the Chemical Heritage Foundation in Philadelphia.

In the following pages, C&EN's Stu Borman, Ron Dagani, Rebecca Rawls, and Pamela Zurer describe some of the seminal developments in the science of chemistry over the past 75 years. The resulting historical perspective is a selective distillation. The events, ideas, and people presented were chosen because they in some way changed the direction of chemistry. Many others could have been included in addition or instead.

Chemical synthesis

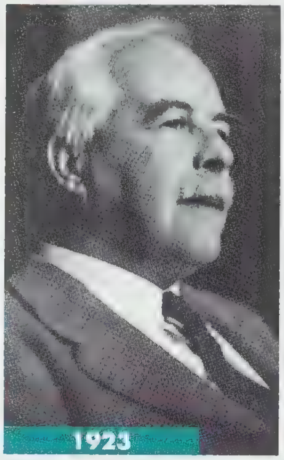
Chemists not only probe the properties and behavior of existing molecules, they also create new ones. The ability to devise new routes to compounds created by nature and to design and construct entirely novel systems lies at the heart of how chemists define their science. The complexity of the molecules and materials that chemists can build, as well as the ease with which they can put their targets together, has increased enormously over the past 75 years.

In organic synthesis, for example, the Nobel Foundation described Hans Fischer's 1929 synthesis of hemin as a "gigantic labor" when he was awarded the Nobel Prize in Chemistry in 1930. Fischer had determined the exact structure of the pigment that gives blood its red color by painstaking synthesis of its decomposition products. He then proved the structure by assembling hemin itself from simple pyrrole starting materials.

Yet Fischer's goal looks modest when compared with the synthetic targets of the past decades. A skeleton analogous to hemin can be recognized as just one small part of Robert B. Woodward's synthetic masterwork, vitamin B-12. Today, chemists pursue goals that are increasingly stereochemically complex: the 64 chiral atoms of palytoxin put together by Yoshito Kishi's group at Harvard University, say, or the 11 fused rings of brevetoxin B assembled by K. C. Nicolaou and coworkers at Scripps Research Institute in La Jolla, Calif. Such achievements have become possible because of countless contributions from numerous researchers advancing chemistry on several fronts.

Chromatographic techniques not available in 1923 now make it easier to isolate and analyze substances of interest. At the same time, spectroscopic and other physical methods allow researchers to rapidly elucidate the structures of unknown compounds.

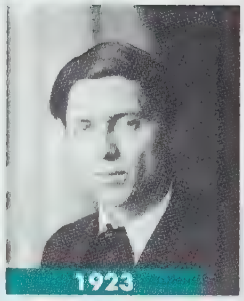
With a solid understanding of the mechanisms by which reactions proceed and the conformations organic molecules are likely to adopt, chemists now can plot the course of their synthetic routes much more accurately. In addition, a wealth of specialized reagents are



Gilbert N. Lewis publishes "Valence and the Structure of Atoms and Molecules."

Courtesy of Othmer Library of the Chemical Heritage Foundation

Hermann Staudinger's proposal that atoms can bond together into huge macromolecules is the subject of lively and heated debate among chemists.



The Svedberg invents the forerunner of the ultracentrifuge.

available to carry out specific transformations. And the very design of organic synthesis—a blend of art and science—has been systematically analyzed and developed on a logical basis.

"At the early part of the century," says Harvard chemistry professor emeritus Frank H. Westheimer, "organic synthesis was carried out by people who had done enormous amounts of lab work and read enormous amounts of literature, so they knew how things had been done before. But they didn't necessarily understand why reactions had gone as they had."

In the 1920s, however, Robert Robinson, Christopher K. Ingold, and others developed the electronic theory of organic reaction mechanisms, focusing on rearrangement of electron pairs as bonds are made and broken. That mechanistic advance in understanding organic chemistry was "one of the great scientific revolutions of the 20th century," says Harvard chemistry professor E. J. Corey.

"It made an enormous mass of information into a coherent intellectual structure," Corey continues. "It permitted chemists to predict the reactivity of an organic compound toward various kinds of reagents. The ability to predict made it possible to take on more and more complicated research projects and syntheses that wouldn't have been possible before mechanistic knowledge came about."

A still more sophisticated way of looking at how organic molecules behave resulted when Derek H. R. Barton spelled out the principles of conformational analysis in 1950. Surveying steroids, Barton pointed out that their reactivity could be understood in light of the conformations the molecules can adopt—that is, the specific three-dimensional arrangements of atoms that can be interconverted by rotation around single bonds.

"Now, everybody looks at everything carefully in three dimensions," Barton says. "When I was a student, nobody ever bothered. My paper showed the relationship between preferred conformation and chemical reactivity.

"The idea of conformational analysis was taken up straightaway by synthetic organic chemists, particularly steroid chemists," Barton continues. "It spread into biochemistry, enzymology, molecular biology—it's key to how enzymes interact with their substrates."

The impact of conformational analysis was "a bombshell," Corey notes. "Most of the complicated organic molecules in the natural world are chiral molecules with stereochemistry. The avalanche of syntheses of such structures didn't set in until we had conformational analysis."

Parallel progress in the tools for synthesis also has allowed chemists to achieve multistep syntheses of much more complicated structures than they could 75 years ago. The exploding number and variety of available reactions and reagents let scientists choose ways to put together and modify molecules with just the right gradation of reactivity and selectivity.

For example, the reaction between dienes and dienophiles to yield six-membered rings was not recognized as general until the work of Otto P. H. Diels and Kurt Alder in the late 1920s. The Diels-Alder reaction is now one of the most versatile and widely used methods for constructing ring systems.

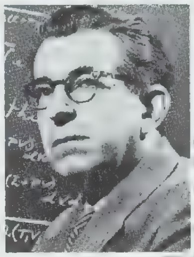
Many other synthetic methods developed over the past 75 years involve inorganic or organometallic compounds. An important way to make carbon-carbon bonds, for instance, was discovered by Georg F. K. Wittig in 1954. In the Wittig reaction, a phosphorus ylide reacts with an aldehyde or ketone, replacing the carbon-oxygen double bond of the carbonyl with a carbon-carbon double bond.

Another example is the homogeneous catalyst reported in 1966 by Geoffrey Wilkinson for hydrogenating double bonds. Soluble chlorotris(triphenylphosphine)rhodium(I) can reduce olefins without affecting other functional groups in a molecule. Other researchers soon were experimenting with chiral phosphine ligands for enantioselective reductions. Chiral ligands of a variety of types now stand at the center of the burgeoning field of asymmetric synthesis.

Wilkinson earlier (in 1952, at the same time as Ernst O. Fischer working independently) had identified the unusual "π-sandwich" structure of ferrocene. The recognition of bonding between the π orbitals of the cyclopentadienyl rings and the *d* orbitals on iron opened the doors to a whole new type of organometallic chemistry. Metallocenes and related compounds now serve as important catalysts in both research and in industrial processes.

In addition to such chemical tools, chemists also employ a logical tool for designing syntheses, an approach Corey calls retrosynthetic analysis. "When I started in research," Corey says, "each synthetic target was taken as an individual problem and solved in an individual way. There

Czech physical chemist Jaroslav Heyrovský invents the polarograph.



Walter H. Heitler (right) and Fritz W. London propose a wave equation for the hydrogen molecule. Their approach is later called the valence-bond theory.

Courtesy of AIP Emilio Segrè Visual Archives

were no general problem-solving principles or procedures people could apply as they did in, say, calculus."

In the 1960s, initially as a way of teaching organic synthesis, Corey systematized a way of thinking about synthetic design strategically. In applying retrosynthetic analysis, chemists start with the target molecule and work backward, identifying strategic bond disconnections, generating a "tree" of pathways and intermediates, and eventually ending up with an array of possible starting points. Corey and W. Todd Wipke, who later founded Molecular Design Ltd. (now MDL), developed interactive computer programs that use the logic of retrosynthetic analysis to analyze molecules and suggest synthetic routes.

"The method greatly accelerates what you can do in a given amount of time if you really understand all the principles," Corey says. "With retrosynthetic analysis, I can take a class of beginning graduate students and teach them in three months to do analyses at the level of experts."

Drug discovery

Today, rationally designed pharmaceutical agents are among the principal targets that chemists strive to reach using the ever-growing arsenal of tools for organic synthesis. But although synthesis of new drugs was also a key goal of chemists in 1923, the concept of "designed drugs" dates from only about 50 years ago. Until then, drug development was based primarily on modification of natural products or existing drugs, rather than on any understanding of how the compounds might work inside the body.

"When we started in the 1940s, there was no rational biochemical approach," says Gertrude B. Elion, emeritus chemist at Glaxo Wellcome, Research Triangle Park, N.C. "Drugs weren't designed to speak of. They were made to look like existing drugs."

Elion and her colleague George H. Hitchings, however, developed a different strategy. In an attempt to interfere in DNA synthesis, they prepared close analogs of the purine and pyrimidine bases found in DNA. Their research at what was then Burroughs Wellcome led to a series of drugs that exploit the differences in the way cancer cells or disease organisms metabolize the modified bases as compared to normal cells. They won the 1988 Nobel Prize in Physiology or Medicine more in recognition of their rational approach to drug design, Elion says, than for the specific compounds they discovered.

When Elion and Hitchings began their long collaboration, they at first did not even know exactly which enzymes were responsible for incorporating the bases into DNA. Today, researchers profit from the gold mine of information available from research on the structure and function of enzymes, receptors, and other biomolecules. With so much detail available, chemists can design molecules to fit in a particular pocket, say, or interfere with a particular amino acid residue.

A prime example is the family of protease inhibitors, the new drugs for treating AIDS that block replication of the human immunodeficiency virus (HIV). Knowledge of the structure of the HIV protease enzyme, published in 1989, aided successful development of such drugs by a number of pharmaceutical companies.

With the advent of combinatorial chemistry in the early 1990s, a new twist was added to drug discovery. Instead of being synthesized one by one, potential therapeutic agents are being systematically produced by the thousands. Molecular building blocks are combined into so-called libraries that can be screened rapidly for biological activity. Through the use of robotics, automated technologies, and sophisticated data handling, the new combinatorial strategy aims to accelerate the process of drug discovery.

Polymers

Chemists were deeply involved in polymer chemistry 75 years ago. Modified natural polymers such as viscose rayon and cellulose acetate had been in production for some time, as had totally synthetic polystyrene. Many chemists were working to achieve a practical process for making synthetic rubber.

They didn't understand the nature of the materials they were dealing with, however.

"Baekeland had invented Bakelite by cooking phenol with formaldehyde," says Westheimer, citing chemist Leo H. Baekeland's resin as an example. "He got this messy, but useful, tarlike stuff. The chemistry of it wasn't even questioned."

The prevailing wisdom in 1923 held that polymers were aggregates of small molecules held together by weak intermolecular forces. The concept of long-chain molecules had just begun to be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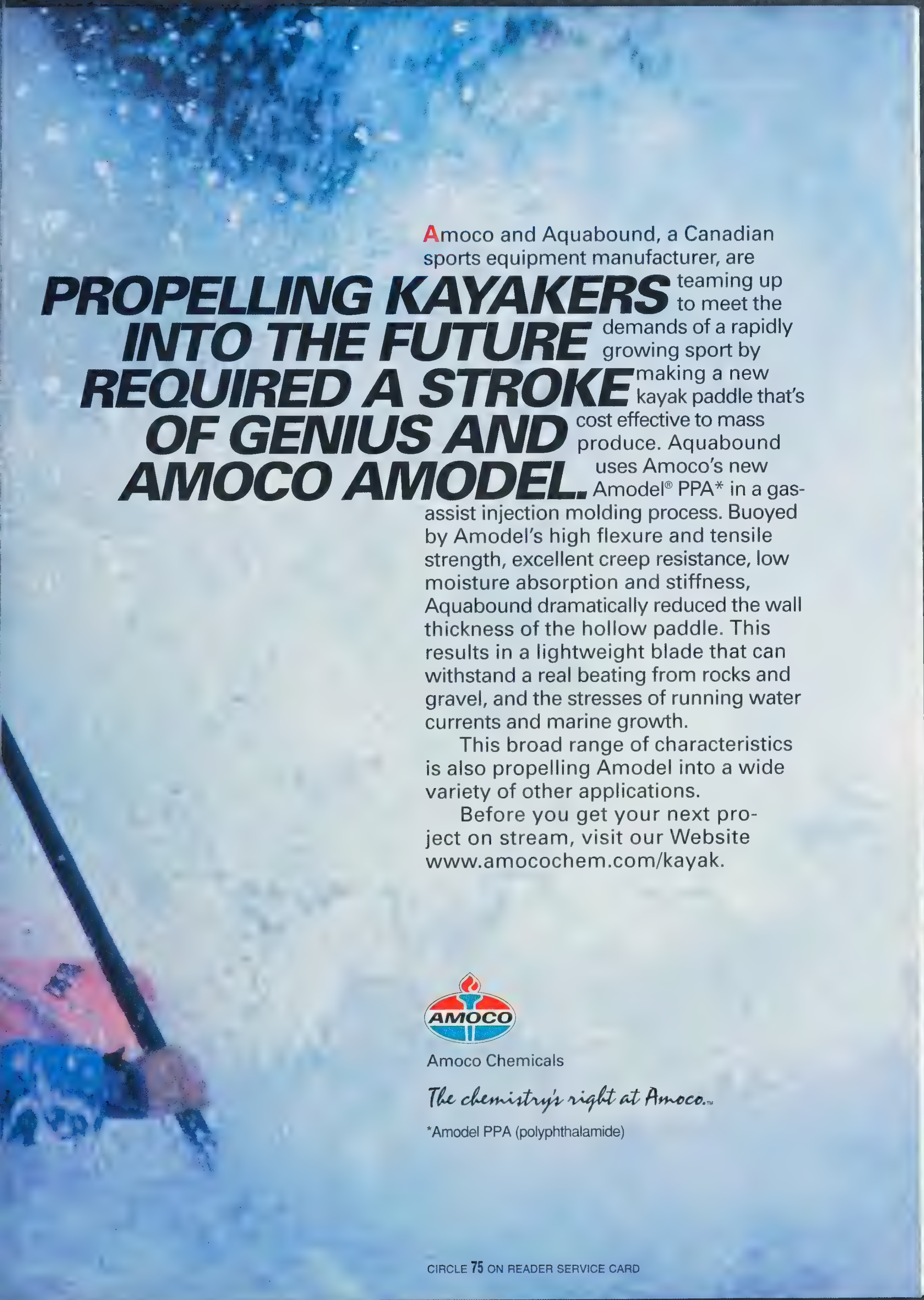
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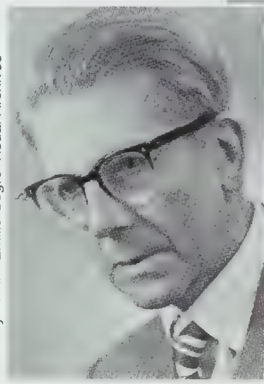
1928

The first pH meters are developed. Arnold Beckman is shown with the "acidimeter" he constructed in 1934, which led to the formation of Beckman Instruments.

1928

Work by Friedrich Hund (below) and Robert S. Mulliken sets the foundation for the molecular-orbital theory.

Photo by Harris & Ewing



Courtesy of AIP Emilio Segrè Visual Archives

championed by German organic chemist Hermann Staudinger, who coined the term macromolecule in 1922. His ideas were at first rejected. But, as evidence from X-ray crystal structures and ultracentrifugation experiments accumulated over the next decade, Staudinger's view of polymers—as thousands of atoms linked by the same type of bonds as smaller organic compounds—came to be accepted.

Staudinger's ideas cleared the path for the creation of a whole new class of synthetic materials: the condensation polymers invented by Wallace H. Carothers and his research group at DuPont. And Carothers' successful preparation of the new polymers helped end the macromolecular debate for good.

Carothers used well-developed methods for putting together low molecular weight organic molecules to synthesize first aliphatic polyesters and then aliphatic polyamides. In 1935, the DuPont researchers created nylon 66 from adipic acid and 1,6-diaminohexane. With DuPont pushing the superior qualities of "artificial silk" for women's hosiery, nylon 66 entered commercial production in 1939.

The next developments in polymer chemistry to truly shift the direction of the science arose from German chemist Karl Ziegler's studies of polymerization catalysts. In 1953, he found that alkyl aluminum compounds combined with certain transition-metal complexes worked wonders on the polymerization of ethylene. Not only was the crystalline product unbranched and of very high molecular weight, but the polymerization also took place at low temperature and pressure.

The following year, Italy's Giulio Natta used a Ziegler catalyst to produce "stereoregular" polypropylene—a material with all of the side-chain methyl groups on the same side of the polymer backbone. By making small changes to the catalyst, Natta discovered, polymerization could be controlled so that side groups could all lie on one side of the backbone, alternate from side to side, or adopt a random configuration.

Ziegler and Natta's discoveries launched a burst of research leading to a wealth of new polymers. One outcome was the attainment of a long-sought goal: synthetic production of the exact duplicate of natural rubber, all-*cis*-polyisoprene.

Zeolites

The 75 years since 1923 also saw the first synthesis of a class of inorganic materials that have grown to be enormously important in several industries: zeolites. Crystalline microporous aluminosilicates, zeolites are three-dimensional networks of AlO_4 and SiO_4 tetrahedra linked by their oxygen atoms. Small ions and molecules can enter the pores of the zeolite lattice and can be separated on the basis of size, which is why the materials are often called molecular sieves.

Today, zeolites with a wide variety of structures and compositions are used as catalysts, adsorbents, desiccants, and ion-exchange materials. Zeolite catalysts, for example, are used to crack petroleum to produce gasoline and jet fuel. The single largest current use is in detergents, where zeolites have largely replaced phosphates.

"The discovery and development of molecular sieve materials is among the most significant advances in inorganic materials in the second half of the 20th century," says Edith M. Flanigen, consultant with UOP in Tarrytown, N.Y. "There are not many other materials that have generated a nearly billion-dollar industry and that are used so extensively."

Natural, or mineral, zeolites that could selectively adsorb compounds were discovered in the 18th century. But it was not until 1948 that Richard M. Barrer reported the first definitive synthesis of an analog of a natural zeolite. Barrer used high temperature and pressure, mimicking the conditions under which he believed the mineral was formed in nature.

Inspired by Barrer's success, Robert M. Milton and Donald W. Breck at Union Carbide prepared a series of synthetic zeolites in the late 1940s and early '50s, including three that the company commercialized—zeolites A, X, and Y. Their gel-based synthetic conditions were much milder than Barrer's. "Milton reasoned that mild conditions would give open, high-porosity zeolites," says their coworker Flanigen.

In 1962, researchers at Mobil Oil introduced a modified zeolite X for fluid catalytic cracking of petroleum to make gasoline. Later that decade, Mobil researchers reported the first high-silica zeolites, known as zeolite beta and ZSM-5. Unlike the hydrophilic zeolites known so far, the high-silica materials were organophilic, preferring organic compounds to water.

In the 1980s, Flanigen and her coworkers created a series of zeolite-type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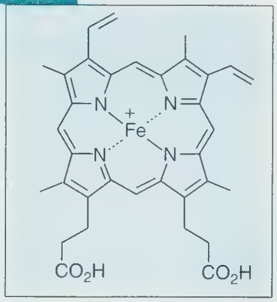
1929



After establishing its structure by synthesizing many degradation products, Hans Fischer completes synthesis of hemin.

1929

Courtesy of AIP Emilio Segrè Visual Archives

Hans A. Bethe publishes a classic paper laying the foundation for crystal field theory.

compounds with frameworks composed of other elements. These aluminophosphates (AlPOs) and related materials—many with structures unlike any known natural or synthetic zeolites—have a surface chemistry between that of traditional alumina-rich zeolites and high-silica zeolites.

"Whenever you have a novel structure you usually get novel properties," Flanigen says. "The advent of the aluminophosphates started an avalanche of people searching for and making a large number of new materials."

The most recent major development has been the discovery of mesoporous molecular sieves by Charles T. Kresge and coworkers at Mobil Oil. Large molecules that don't fit into the 10- to 12-Å-diameter pores of zeolites or AlPOs can fit into the 20- to 100-Å pores of the mesoporous structures, significantly expanding the range of chemistry that can go on inside.

Superconductors and fullerenes

Just as synthetic zeolites did in the 1950s, the discovery of two other types of materials in the 1980s sent scientists in new directions. Unlike zeolites, however, high-temperature superconductors have not yet cracked any major markets. And fullerenes are not being used commercially at all. But research in both areas is booming.

The phenomenon of superconductivity (the ability to conduct electricity with no resistance) was discovered in 1911 in mercury cooled to liquid helium temperatures. From then until the mid-1980s, scientists looked mostly among metallic alloys for materials that became superconducting at temperatures high enough to be practical. But for decades, not much progress was made in the search for so-called high-temperature superconductors. "We were all frustrated," says Paul C. W. Chu, professor of physics and director of the Texas Center for Superconductivity at the University of Houston.

Then, in early 1986, J. Georg Bednorz and K. Alex Müller of IBM Zurich Research Laboratory in Switzerland discovered that lanthanum copper oxide doped with barium became superconducting at the unprecedented transition temperature (T_c) of 35 K. At first, many researchers thought their results were too good to be true. But as others confirmed the IBM workers' findings and rumors of even higher T_c began to circulate, a flurry of research began on the relatively unexplored oxides. Researchers at labs around the world worked nonstop, many reporting their results for the first time at a tumultuous session at the American Physical Society's March 1987 meeting in New York City.

Even before that "Woodstock of physics," however, the word was out about Chu and his coworkers finding superconductivity at a T_c of 93 K in a yttrium barium copper oxide. That temperature was high enough to be reached by cooling with cheap liquid nitrogen, which boils at 77 K.

"When I saw Chu's resistivity curve for the first time, my heart stopped," says Paul M. Grant, now an executive scientist at the Electric Power Research Institute (EPRI), Palo Alto, Calif., but at IBM Almaden at that time. "Everybody believed his data. We were totally convinced it was superconductivity."

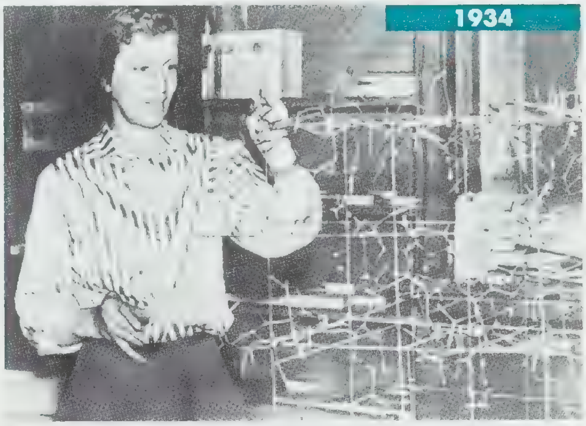
In the decade since, many other superconducting copper oxides have been identified. In addition to unraveling the science of superconductivity at such high temperatures, much current research focuses on methods to process the materials for practical applications. Viable technology for producing wires for power transmission, although still expensive, is already available, Grant says.

Chu notes that the intense study of the fragile superconducting ceramics also has led to improvement in existing techniques for characterizing materials and the development of new methods. For example, he points to the discovery that buckyballs doped with alkaline metals act as superconductors. "The researchers knew how to quickly and accurately determine the existence of superconductivity in the original material, even though it was not so pure, as a result of work on high-T_c materials," he says.

Superconducting buckyballs are just one outgrowth of the work that has blossomed since Richard E. Smalley, Robert F. Curl Jr., and Harold W. Kroto and coworkers discovered a new form of elemental carbon in 1985. The structure of buckminsterfullerene—also known as C_{60} or buckyball—is a spherical arrangement of carbon atoms composed, like a soccer ball, of interconnecting hexagons and pentagons.

Research on fullerenes has accelerated since 1990, when a method for producing large quantities from graphite electrodes was developed. In the past few years, studies of carbon nanotubes—

Harold C. Urey discovers deuterium. He is shown studying fossil shells in which variations in isotope distribution give hints of seasonal climate variations.



Dorothy Crowfoot Hodgkin, along with J. D. Bernal, records the first X-ray diffraction pattern of a protein, pepsin. She is shown with a model of the crystal structure of vitamin B-12, which she helped to clarify in 1956.

extended tubular members of the fullerene family—have overtaken work on the fullerenes themselves. Smalley foresees a whole new nanotechnology arising from carbon nanotube research.

Expanding arsenal of tools

As Chu points out, the ability of scientists to answer questions depends heavily on the tools they have available. Some of the most important new tools developed over the past 75 years have been analytical instruments. But fundamental technologies such as the laser and structural analysis tools like X-ray crystallographic instruments have made enormous contributions over the past three-quarters of a century as well.

Each new instrumental technique, as it has been developed, "has opened up a realm of looking at things," says chemistry professor George M. Whitesides of Harvard University. "If you can't measure it and can't analyze it, you can't understand it, and there's not much you can say about it."

For example, he says, "organic chemistry could not exist as it does today without NMR [nuclear magnetic resonance] spectroscopy and mass spectrometry. Organic synthesis depends on being able to analyze a structure to tell what it is and how far you have progressed in synthesizing it. There would be no inorganic chemistry, as far as I can tell, without X-ray crystallography and ultraviolet spectroscopy, because those have been the most important set of eyes that have been used in that field. And the big movement in chemistry toward biology has been in large part because of NMR and crystallography for determining structures of proteins and sequencing methods for determining sequences of nucleic acids."

Lasers

One of the tools of fundamental importance to the progress of chemistry over the past 20 years or so is the laser. "Lasers have transformed chemical research and provided unprecedented limits of detection, probing, and control of matter," says professor of chemical physics Ahmed H. Zewail of Caltech. "The scope of application is enormous and in all areas of research."

According to chemistry professor Richard N. Zare of Stanford University, "Lasers have altered chemistry in a remarkable way. No major chemical research laboratory exists that doesn't use lasers, from spectroscopy to novel applications such as manipulating single molecules and small particles in solution, following chemical reactions in real time, and studying how bonds are made and broken.

"One of the main reasons why lasers are so useful is that they are so bright," says Zare. "What that means, for example, is that Raman spectroscopy—which I would say was nearly totally dormant before the birth of the laser—has been revitalized. It is so easy to take lasers for granted, and it is easy to forget how many different places they are now used. For example, without a helium-neon laser to count the fringes, modern Fourier-transform infrared (FTIR) instruments would not be possible. And if we had to rely on copper wire as opposed to optical fiber, our ability to communicate large amounts of data would be severely limited."

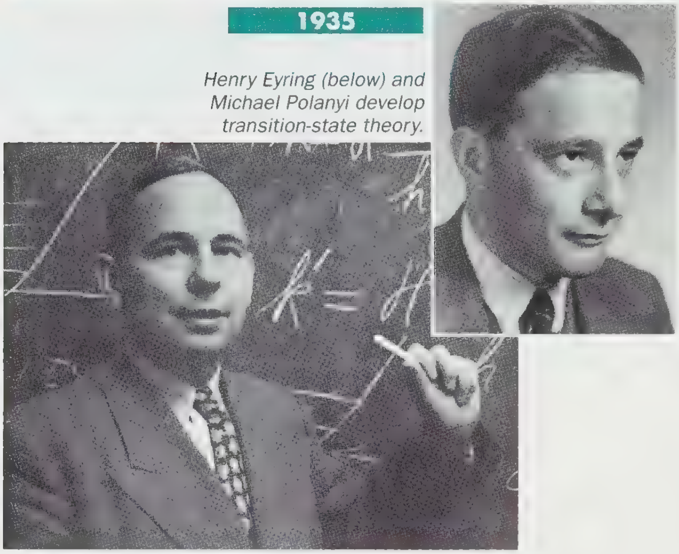
The story of the laser can be traced back to physicist Albert Einstein, who in 1916 proposed that a photon hitting an atom in an excited energy state could cause the atom to give off another photon of the same energy. The essential requirement for generation of a laser is that the number of excited-state atoms exceeds the number of lower energy atoms in the laser medium—a condition called a population inversion because lower energy states normally tend to predominate.

The maser, the microwave-emitting precursor of the laser, was conceived and built in the early 1950s, and the first optical laser was built in 1960. Commercial lasers produced soon thereafter found their way into many chemical laboratories.

In the 1960s, chemical lasers, which use chemical reactions to produce population inversions, were conceived and developed. The major strength of chemical lasers turned out to be not in research but in their ability to generate high power for use in military laser weapons. The same decade saw the discovery of nonlinear optical phenomena (which made a wider range of laser frequencies accessible) and the development of semiconductor lasers, ion lasers, and pulsed and continuous dye lasers. Major laser advances from the 1970s on have included the development of excimer lasers, tunable dye lasers, free-electron lasers, and femtosecond lasers. And just last year, a physics group reported the first atom laser, which emits coherent atoms instead of radiation.

1935

Henry Eyring (below) and Michael Polanyi develop transition-state theory.



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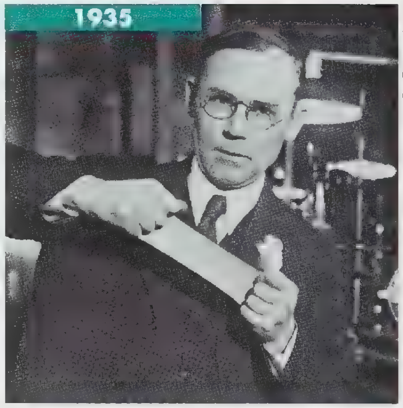


Wallace Carothers invents nylon. Carothers is shown stretching neoprene, a 1930 DuPont discovery.

DuPont photo

Lasers have made it possible to observe chemical reactions, including bond breaking, bond making, and transition states, and reaction mechanisms have been solved with lasers. "Lasers give us the time resolution and the coherence needed to study the dynamics of the chemical bond," says Zewail. "Without lasers, it would be impossible to see chemical and biological events occurring on the time scale of atomic motion—the femtosecond scale."

Lasers have also made it possible to achieve bond-specific chemistry—reactions of polyatomic molecules at specific bonds, yielding selective products. Laser vaporization of graphite was used to produce the first fullerenes in 1985, and lasers can be used to produce fullerenes and carbon nanotubes in research quantities. Lasers have enabled researchers to confirm quantum mechanical theories of reaction dynamics by experimental means. And they have been used to analyze components inside single living cells and cell organelles and to monitor reactions of individual molecules.

"The laser has allowed great creativity and inventiveness and will continue to, as we think of how to use coherent radiation to solve interesting chemical problems," says Zare.

NMR spectroscopy

Since its beginnings, "NMR spectroscopy has bloomed into a major tool in analytical chemistry, a valuable method for studying physical phenomena from kinetics to superconductivity, a technique in structural biology that rivals X-ray crystallography, a routine procedure for imaging in diagnostic radiology, a way to study metabolic function in humans and animals, and an evolving method in materials science." So wrote NMR Section Chief Edwin D. Becker of the National Institutes of Health in a historical review of the field [*Anal. Chem.*, **65**, 295A (1993)].

The first NMR observations were made in 1938 by physicist Isidor I. Rabi of Columbia University using molecular beams in high vacuum. NMR spectroscopy of bulk material was first carried out in 1945 by two physics groups working independently—those of Felix Bloch at Stanford University and Edward M. Purcell at Harvard University.

Bloch and coworker William W. Hansen filed a patent application on their work and signed an exclusive license with Varian Associates, Palo Alto, Calif., which was the first company to produce a commercial instrument.

In the early 1950s, researchers discovered that resonances of hydrogen nuclei located in different positions in a molecule were separated in a spectrum. This phenomenon, the chemical shift, is what makes it possible to use NMR to determine molecular structure.

In the mid-1950s, researchers determined for the first time that nuclear spins could interact with each other to produce spin-spin splittings of resonances, another key element of modern NMR analysis. And double-resonance techniques such as the nuclear Overhauser effect were discovered, facilitating both spectral peak assignment (to specific atoms) and molecular structure determination.

Initially, chemical NMR spectrometry focused primarily on proton analysis, but in 1957, chemistry professor Paul C. Lauterbur, now at the University of Illinois, Urbana-Champaign, introduced carbon-13 NMR—a technique now widely used for the study of organic and biological compounds.

NMR instruments of the 1950s were primitive by today's standards. For example, in 1953 commercial instruments used a proton radiofrequency of 30 MHz, whereas 800-MHz instruments are available today. For a particular nucleus, radiofrequency is proportional to magnetic field strength and resolution (the ability to spread out chemical shifts). Until the mid-1960s, increasingly larger iron-core electromagnets were used to boost NMR field strength, but at a radiofrequency level above 100 MHz this became impractical—a problem solved by the development of high-field superconducting magnets, which were first incorporated into commercial instruments in 1966.

Also in 1966, chemist Richard R. Ernst and physicist Weston A. Anderson of Varian Associates developed FT-NMR, a technique in which short radiofrequency pulses are used to excite resonances over a wide band of frequencies simultaneously. "The development of FT-NMR methods truly revolutionized the field," Becker tells C&EN. "Not only could sensitivity be enhanced by time averaging in a practical manner, but the speed of the pulse FT method could be exploited alternatively to study fast processes such as chemical reactions and time-dependent NMR phenomena."

The power of NMR was initially re-

1937

Hans Krebs unites respiration and the metabolic breakdown of carbohydrates in a catalytic reaction cycle.

1938

Courtesy of Hagley Museum and Library

DuPont scientists (from left) Jack Rebok, Robert McHarness, and Roy Plunkett discover fluorocarbon polymers. (Photo is a reenactment.)

Photo by Ray Huff Studios

1939

Linus Pauling publishes "The Nature of the Chemical Bond and the Structure of Molecules and Crystals."

stricted largely to liquid samples because conventional methods applied to complex solid samples yielded only broad, featureless spectra. But in the late 1960s and 1970s, the development of multiple-pulse techniques and the application of methods such as cross polarization and magic-angle spinning led to the growing use of solid-state NMR in chemistry.

"The foundation of modern solid-state NMR is a class of intellectual principles and technologies that derive to a large extent" from the school of chemistry professor John S. Waugh of Massachusetts Institute of Technology, says chemistry professor Alexander Pines of the University of California, Berkeley. "Today, high-resolution solid-state NMR is widely applied to materials such as semiconductors, catalysts, polymers, and proteins."

In the 1970s, physicist Jean Jeener of the Free University of Brussels, Belgium, conceived, and Ernst and others developed, pulsed two-dimensional NMR, which provided more powerful ways to assign spectral peaks to atoms in complex molecules. Later, three- and even four-dimensional NMR techniques were developed as well.

The advent of multidimensional techniques led to the first NMR determination of the three-dimensional structure of a protein in 1985. Today, NMR is widely used to obtain structures of proteins in solution.

Nevertheless, the general public was not at all familiar with NMR technology until magnetic resonance imaging (MRI) appeared on the scene. In 1973, Lauterbur first demonstrated that spatial images of living objects could be obtained by imposing magnetic-field gradients across them. Since then, MRI has become a standard medical diagnostic technique worldwide and has had an enormous economic impact.

X-ray crystallography

Like NMR, X-ray crystallography has had a tremendous influence on chemistry. "X-ray crystallography is a marvelous technique. It's still the single most important structure-determining technique," says John Meurig Thomas, professor of chemistry at the Royal Institution of Great Britain in London.

The diffraction of X-rays was first demonstrated in 1912 by Max von Laue. The application of X-ray diffraction to determining the structure of crystals was discovered one year later by William Lawrence Bragg—who, with his father, William Henry Bragg, obtained the first X-ray structures.

Initially used to observe crystals of elements and simple polar inorganic compounds such as calcite, X-ray crystallography has evolved to such an extent that structures of organic molecules, molecules of life, and even whole viruses are no longer beyond its reach.

In the 1950s, researchers developed direct methods for phase determination, which increased the speed with which crystal structures of small molecules could be obtained. "In the 1960s, the power of direct methods that had been developed a decade earlier began to dramatically shorten the time to analyze crystal structures," says chemistry professor Jon C. Clardy of Cornell University. "Improvements in direct methods have continued, and recently, a structure with over 1,000 atoms was successfully solved."

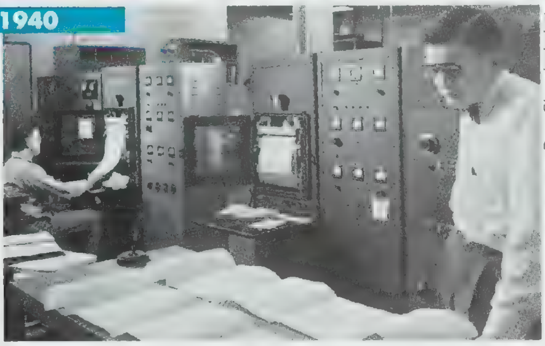
Clardy notes that "the development of synchrotron X-ray sources, which are many orders of magnitude brighter than conventional laboratory sources, dramatically enhanced the range of structural problems that could be studied. The intense beam allowed small samples to be studied, and the variable wavelength has added powerful new phasing techniques." Synchrotron sources also provide the basis for time-resolved crystallographic techniques, which can be used to obtain snapshots of protein structural changes on a nanosecond time scale and to depict molecular structures in action.

Chromatography

In the first decade of the 20th century, Russian botanist Mikhail Tswett showed how the components of a mixture could be separated by differential migration using a technique he called chromatography. Following his example, researchers for several decades thereafter practiced classic liquid chromatography (LC), which uses an adsorbent as the stationary phase and a liquid mobile phase (eluent). LC became particularly popular in the 1930s for the separation of complex natural samples.

In 1941, Archer J. P. Martin and Richard L. M. Synge of the Wool Industries Research Association, Leeds, England, first reported the concept of liquid-liquid partition chromatography—the idea that solutes could be separated by a series of multiple partitioning steps between two immiscible solvents, one of which (the

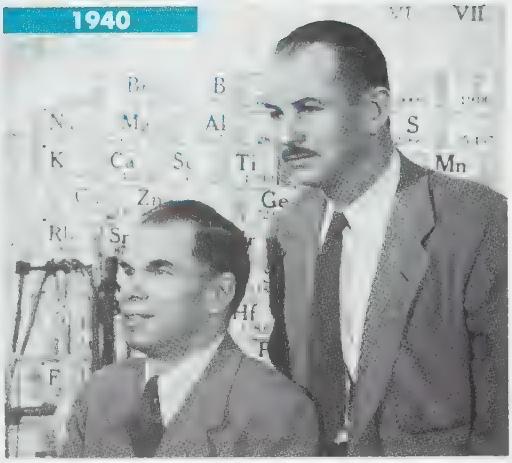
1940



Dow Chemical photo

Physicist Alfred O. C. Nier of the University of Minnesota constructs the first sector mass spectrometer. In this 1951 photo, MS technician Herb Woodcock (left) and group leader Fred McLafferty, then at Dow Chemical, operate a Westinghouse instrument.

1940



Edwin McMillan (standing) and colleagues produce neptunium. The following year Glenn T. Seaborg (seated) and colleagues produce the second transuranium element—plutonium.

stationary phase) could be fixed on a support.

According to chromatographer Leslie S. Ettre, retired from Perkin-Elmer, Norwalk, Conn., "Partition chromatography became popular through paper chromatography, where the stationary phase was distributed on the surface of pieces of filter paper. Paper chromatography was introduced in 1944 by Martin and coworkers, and it became immediately very popular among biochemists." Later on, partition chromatography led to the development of high-performance liquid chromatography (HPLC), which is used to separate nonvolatile and thermally labile substances.

Chemistry professor Barry L. Karger of Northeastern University, Boston, points out [*J. Chem. Ed.*, **74**, 45 (1997)] that in the early 1960s, LC instrumentation was generally homemade and primitive by modern standards. "Since efficiency was quite low, columns were typically a meter or more in length, and multistory columns were sometimes used to obtain the necessary resolution. Separations took hours and sometimes days to complete. Ph.D. theses in the biological sciences could consist of a multiyear effort in the isolation of a protein from a tissue sample."

But improvements were on the way. Martin and Synge's classic 1941 paper on partition chromatography had predicted that HPLC would be possible if small stationary-phase particles were used and high pressure differences were applied across the column. In the 1960s, chemistry professor J. Calvin Giddings of the University of Utah, Salt Lake City, confirmed these predictions using theoretical models. Chemical engineering professor Csaba G. Horváth of Yale University and chemistry professor J. F. K. Huber, then at Eindhoven University of Technology, the Netherlands, "were the first to appreciate and apply these predictions to the development of actual HPLC systems," says Lloyd R. Snyder of LC Resources, Orinda, Calif.

Since then, improvements in separation efficiency have resulted from reductions in particle size and the development of innovative column packings, such as controlled-porosity particles and chemically bonded packings. Bonded phases made possible the revival in the early 1970s of reversed-phase LC, which had been dormant since its conception in 1950. Reversed-phase LC, in which separations are carried out with aqueous or mixed organic-aqueous mobile phases, has proven particularly applicable to separations of biological molecules such as peptides and proteins. Biochemical and pharmaceutical separations were also aided by the 1980 introduction of chiral stationary phases, which can be used to separate enantiomers.

Other forms of LC that have become a key part of the scientific armamentarium are ion chromatography and affinity chromatography. Ion chromatography, developed in the early 1970s, is a technique in which ions—including charged biological molecules such as amino acids and proteins—are separated on ion-exchange resins and measured by conductivity detection. And affinity chromatography, in which noncovalent binding interactions cause selective retention, is particularly useful for biological samples.

Meanwhile, gas chromatography (GC), with a gaseous mobile phase and adsorbents as stationary phase, was developed and used by a number of researchers in the 1940s, although the operating modes were different from those used today. "The first real gas chromatograph—essentially identical to our present-day systems—was put together by professor Erika Cremer of the University of Innsbruck, Austria, in 1947," says Ettre. Commercial gas chromatographs were first introduced in 1954 and 1955 by several companies, including Perkin-Elmer. By 1957, a number of other companies had entered the commercial GC market.

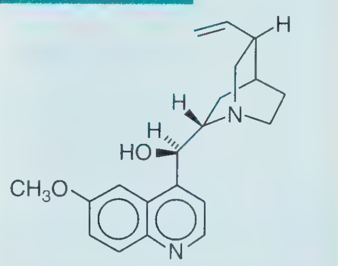
Most early gas chromatographs used thermal conductivity detectors, which respond to all substances but don't have high sensitivity. But the late 1950s saw the introduction of the argon ionization detector (later modified into the electron-capture detector) and flame-ionization detector, which were much more sensitive.

The 1950s and early 1960s also saw the first glimmerings of the use of infrared (IR) spectroscopy and mass spectrometry (MS) instruments as GC detectors. Both GC-IR and GC-MS provide more information about the chemical identity of separated components than "plain-vanilla" GC does.

Mass spectrometry

Since its beginnings about 100 years ago, MS has become a ubiquitous scientific tool. "Scientific breakthroughs made possible by MS have included the discov-

1944



Robert B. Woodward and William von E. Doering synthesize quinine.

1946

Melvin Calvin begins to use carbon-14 labeling to trace the uptake of CO_2 in photosynthesizing bacteria.

ery of isotopes, exact determination of atomic weights, characterization of new elements, quantitative gas analysis, stable-isotope labeling, fast identification of trace pollutants and drugs, and characterization of molecular structure," says chemistry professor Fred W. McLafferty of Cornell University.

In the first decade of the 20th century, J. J. Thomson of the Cavendish Laboratory at the University of Cambridge, the discoverer of the electron, constructed the first mass spectrometer—then called a parabola spectrograph—for the determination of mass-to-charge ratios of ions.

Around 1920, physics professor A. J. Dempster of the University of Chicago developed a single-focusing magnetic-deflection instrument. Spectrometers based on Dempster's design were used in the petroleum industry during World War II for quantitative analysis of organic gas mixtures, and this type of instrument is still in use. Dempster also developed the electron-impact source, which uses a beam of electrons from a hot filament to ionize volatilized molecules—a device found in many modern mass spectrometers.

In the 1930s to 1950s, high mass resolution double-focusing instruments were developed "for the purpose of accurately determining the exact atomic weights of the elements and their isotopes," says chemistry professor Klaus Biemann of MIT. Magnetic deflection instruments, both single focusing and double focusing, "dominated high-performance mass spectrometry well into the 1990s," says Biemann. "The cheaper time-of-flight, quadrupole, and ion-trap mass spectrometers evolved in parallel to the more expensive magnetic-deflection instruments."

In a time-of-flight analyzer, ions are separated by differences in their velocities as they move in a straight path toward a collector in order of increasing mass-to-charge ratio. Time-of-flight MS is fast and has proven applicable to chromatographic detection and the determination of large biomolecules.

The direct coupling of GC to MS was first achieved in the mid-1950s. "The combination of gas chromatographs with mass spectrometers was, I think, the first 'hyphenated' analytical technique," says Biemann. Today, GC-MS is used for environmental analysis, forensics, drug testing, and pharmacological studies.

A type of instrument that proved to be ideal for coupling to a GC was the quadrupole mass filter. In a quadrupole device, radiofrequency energy and an electrical potential applied to four cylindrical metal rods are used to separate ions. Although quadrupole mass spectrometers are not as accurate and precise as double-focusing instruments, they are fast, which is important for GC detection.

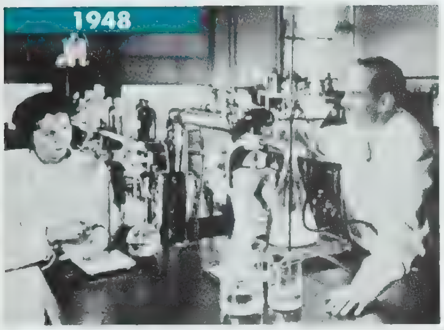
The quadrupole ion trap, a device in which a radiofrequency voltage is used to generate a quadrupole electric field, was originally introduced commercially as a GC detector. But today, ion-trap instruments also serve as LC detectors and stand-alone mass spectrometers.

Novel ionization techniques have extended the capabilities of MS beyond those afforded by the electron-impact source. In field ionization, the sample is ionized in a strong electric-field gradient. A variation, field desorption, widened the range of MS by making it possible to study nonvolatile or thermally unstable compounds. "Field desorption really opened the door for biological MS by demonstrating feasibility," says chemistry professor Ronald D. Macfarlane of Texas A&M University, College Station.

In the 1960s, chemical ionization was developed as a "soft" ionization technique, in which volatilized molecules are ionized by reaction with gas ions. Chemical ionization is gentler than electron-impact ionization and generates fewer fragment ions.

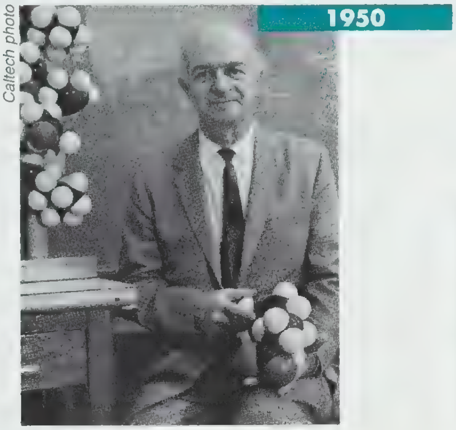
Two recently developed MS techniques that have had a major impact on the ability to determine large biomolecules are electrospray ionization (ESI) and matrix-assisted laser desorption/ionization (MALDI). In ESI, highly charged droplets dispersed from a capillary in an electric field are evaporated, and the resulting ions are drawn into an MS inlet. In MALDI, sample molecules are laser-desorbed from a solid or liquid matrix containing a highly UV-absorbing substance.

Techniques such as ESI and MALDI have permitted large biomolecules to be analyzed by low-cost MS and MS/MS instruments of the quadrupole, ion-trap, and time-of-flight type. This feature has made biological MS available to hundreds of researchers who do not have access to one of the expensive magnetic sector machines. "MALDI and ESI now promise a greatly expanded future with molecular characterization of proteins, DNA, and other large molecules using instru-



Gertrude B. Elion and George H. Hitchings develop biochemistry-based strategy for synthesis of new drugs.

Caltech photo



Linus Pauling proposes an α-helix as a common arrangement of amino acid residues in proteins.

Derek H. R. Barton spells out the principles of conformational analysis.

ments providing high sensitivity, specificity, and speed at lower cost," says McLafferty.

Electroanalytical chemistry

"Electrochemical methods like cyclic voltammetry are today routinely employed by all kinds of chemists, biochemists, and even physicists as part of their experimental tools," says Royce W. Murray, chemistry professor at the University of North Carolina, Chapel Hill, and editor of *Analytical Chemistry*. "There also have been fusions of electrochemical methodology with materials science that have, for example, led to the solid-state oxygen sensors found in so many automobile engines."

The beginnings of analytical electrochemistry can be traced to 1922, when Czech physical chemist Jaroslav Heyrovský developed polarography, a technique in which a dropping mercury electrode is used to obtain current-voltage curves for reducible or oxidizable compounds in solution. In 1925, Heyrovský and coworker Masuzo Shikata invented the polarograph, an instrument for recording such curves automatically. The discovery of the three-electrode potentiostat in 1942 widened the applicability of polarography to sample types that had previously been inaccessible.

In the 1950s and 1960s, multipurpose electrochemical instruments based on operational amplifiers (op amps) were developed in academia. A commercial version of such an instrument, the model 170 electrochemical analyzer from Princeton Applied Research Corp., Princeton, N.J., "was revolutionary for its time in that it permitted the electrochemist to perform a wide variety of different measurements on the same solution simply by changing some front-panel controls, and in that it could be operated by someone who had no knowledge of electronics," says physical chemist Jud B. Flato, who led a Princeton Applied Research group that developed the instrument. A similar multipurpose electrochemical instrument based on op amps was developed by Cambridge Instruments in England at about the same time.

One of the techniques popularized by op-amp-based instruments was pulse polarography, a method that improved the detection limits of conventional polarography by about two orders of magnitude. Pulse polarography was an offshoot of square-wave polarography, a technique developed in the early 1950s by Geoffrey C. Barker of the Atomic Energy Research Establishment, Harwell, U.K. Barker's technique was developed further by others in the 1970s and has evolved into a technique now known as Osteryoung square-wave voltammetry.

In 1983, an all-digital electrochemical analyzer that required no knobs, buttons, or gain controls to carry out 38 different types of electrochemical techniques was introduced by Bioanalytical Systems, West Lafayette, Ind. The current version of this instrument is controlled by a personal computer.

Peter T. Kissinger, professor of chemistry at Purdue University and president of Bioanalytical Systems, notes that research on computer modeling of electrochemical processes and the development of algorithms for simulation of electrochemical experiments have been responsible for major advances in electrochemistry. As a result, "work that required overnight computer runs can now be done on a Pentium computer in less than five seconds," says Kissinger.

An electrochemical device that has had an exceptionally broad impact on scientific research is the glass electrode. Invented in 1906, the glass electrode is used to measure hydrogen-ion concentration. The first pH meters based on it were created in 1928.

In 1934, chemistry professor Arnold O. Beckman at Caltech built a pH meter for a colleague. He tried to interest various companies in manufacturing the device, but they declined. As a result, he formed National Technical Laboratories, based in Pasadena, Calif., which developed the first commercial pH meters and was the beginning of what is now Beckman Instruments, Fullerton, Calif.

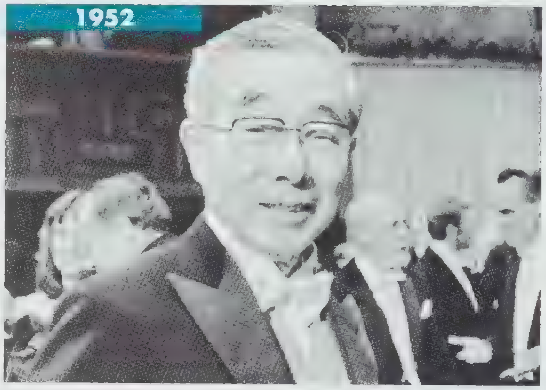
Over the years, Beckman, other companies, and academic researchers made great improvements in pH meters as they developed into their modern form, with higher stability glass electrodes, microprocessor control, and light-emitting diode readouts. Beginning in the 1950s, electrodes were also developed for other ions, such as F^-, Na^+, K^+, and Ag^+. The pH meter and ion-selective electrode have now become indispensable scientific tools.

Atomic and molecular spectroscopy

Developments in atomic emission spectroscopy (AES), atomic absorption spectroscopy (AAS), ultraviolet-visible spectroscopy (UV-vis), IR spectroscopy, and Raman spectroscopy have revolutionized

Courtesy of Carl Djerassi

Carl Djerassi synthesizes norethindrone, the basis of the first effective oral contraceptive.



Courtesy of Roald Hoffmann

Kenichi Fukui introduces the frontier orbital theory of reactions. In this photo, he is receiving the Nobel Prize in Chemistry in 1981.

atomic and molecular analysis over the past 75 years.

In AES, atoms excited in flames, arcs, sparks, or plasmas emit optical frequencies that can be used to identify elements in samples and determine their concentrations. AES was known in the 19th and early 20th centuries, but 1930 through 1960 was a period of particularly rapid development, spurred in large part by growing interest in its use for metals analysis in the aluminum and steel industries. Electronically controlled spark sources developed in the late 1960s improved the precision of spark AES, were marketed commercially, and are still in extensive use.

In the mid-1960s, Stanley Greenfield and coworkers at Albright & Wilson Ltd., Oldbury, England, and chemistry professor Velmer A. Fassel and coworkers at Iowa State University, Ames, independently developed the inductively coupled plasma (ICP) atom source as an alternative to arc and spark sources, and commercial ICP-AES instrumentation appeared in 1972. ICP-AES offered a number of advantages over arc and spark AES—improved precision, wider dynamic range, greater freedom from interferences, ease of use, and more ready applicability to the analysis of solutions. As a result, ICP-AES has largely displaced arc and spark techniques for many elemental analysis applications. But arc and spark AES do not require dissolution of metal samples (as ICP-AES does) and thus are still widely used in the metals industry.

In addition to being a good atom source for AES, the ICP proved "to be an ideal sample introduction system for the mass spectrometer," says retired spectroscopist Walter Slavin of Perkin-Elmer. "The ICP-MS business is already almost as large as that of ICP-AES and is growing very much faster than any other part of atomic spectroscopy." Slavin points out that diode array detectors, which detect a range of wavelengths simultaneously and therefore provide a speed advantage, are now incorporated into many commercial ICP-AES instruments in place of conventional photomultiplier detectors.

In AAS, light from a source passes through a flame into which a sample is aspirated, and attenuation of the beam by sample atoms in the flame is compared to standards to determine elemental concentrations. The concept of atomic absorption dates back to the 19th century, but use of AAS as a general analytical technique was first proposed in 1955 by physicist Alan Walsh of the Commonwealth Scientific & Industrial Research Organization's Division of Industrial Chemistry, Melbourne, Australia, and independently by physicists C. Th. J. Alkemade and J. M. W. Milatz of the University of Utrecht, the Netherlands. The Australian and Dutch researchers pointed out that AAS had overriding advantages over AES—enhanced sensitivity and specificity and lower susceptibility to interferences—despite its inability to perform simultaneous multielement analysis, as AES could do.

Walsh worked hard in the 1950s to promote AAS. One of his suggestions was the use of hollow cathode lamps (which provide very narrow spectral lines and exhibit low noise) as light sources to increase the technique's sensitivity and linear working range. Eventually, his efforts to popularize AAS succeeded, and commercial instrumentation, complete with hollow cathode lamp sources, emerged in the early 1960s.

In 1959, a heated graphite furnace atomizer was developed as an alternative to the conventional AAS flame atomizer by Boris V. L'vov of the department of analytical chemistry at Leningrad State Technical University (now St. Petersburg State Technical University). The graphite furnace, which offered higher sensitivity and the ability to analyze smaller samples, was also eventually introduced in commercial AAS instrumentation.

In UV-vis spectroscopy, the absorption of UV and visible radiation is used primarily to determine molecules and ions in solution. UV-vis spectroscopy was practiced in the 19th and early 20th centuries, but its popularity grew immensely in the 1940s after Beckman Instruments introduced its inexpensive and easy-to-use model DU single-beam spectrophotometer. After World War II, double-beam UV-vis instruments were introduced, permitting simultaneous monitoring of sample and reference channels and thus improving the convenience with which the technique could be carried out. Since then, UV-vis instruments have been spiffed up considerably with microprocessor controls, computer interfaces, and diode array detectors.

The popularity of IR spectroscopy (which probes vibrational energy levels of molecules) for sample identification, component analysis, and organic structure determination, among other applications, began to ratchet up in the 1930s and early 1940s. Commercial instruments from U.S. manufacturers such as Beckman Instru-

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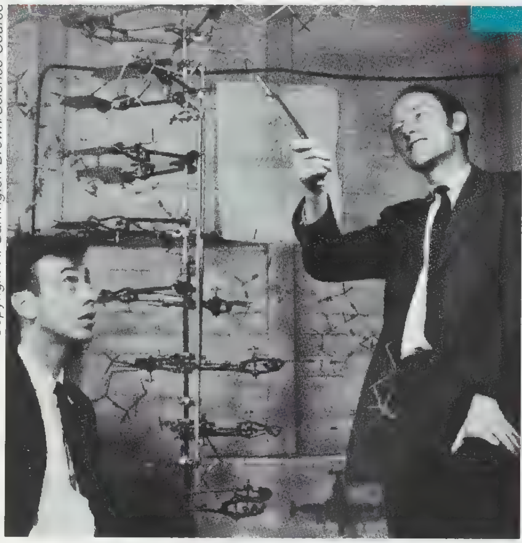


1953

James D. Watson (left) and Francis Crick propose a double-helical structure for DNA.

AP/Wide World photo

1953

Stanley L. Miller (shown) and Harold Urey produce amino acids from primordial soup.

ments and Perkin-Elmer began to appear during World War II. IR spectroscopists made major contributions to a number of important research projects during the war, including enemy-fuels analysis, the synthetic rubber program, and the effort to characterize and synthesize penicillin.

Double-beam recording IR spectrometers, which monitor the absorption of light by a sample and a reference simultaneously, were developed and released commercially in the 1940s. "The development of commercial double-beam IR instruments, of which the Perkin-Elmer model 21 was an outstanding example, turned IR into a technique that became very widely used by organic chemists," says chemistry professor Norman Sheppard of the University of East Anglia, Norwich, U.K. "Until NMR took general hold in the early 1960s, it was the principal method of analysis of organic structures and remained very versatile, as samples could be studied in very small quantities in the solid as well as solution states."

In 1950, Peter B. Fellgett of Cambridge University proposed that dramatic improvements in the signal-to-noise ratio of IR spectroscopy could be realized by using FT analysis to obtain IR spectra. Initially, the computations required to calculate the transforms were so laborious that any advantages of the technique were negated. But the publication in 1965 of the Cooley-Tukey fast FT algorithm changed that, and FTIR entered a takeoff phase. Today, it is the dominant form of commercial IR spectroscopy and is widely used both for organic analysis and GC detection.

Raman spectroscopy monitors changes that occur in source radiation when it interacts with the vibrational energy levels of sample molecules. The technique, discovered in 1928 by Indian physicist Chandrasekhara Venkata Raman, provides information complementary to that obtained from IR spectroscopy.

Recording of Raman spectra "was initially by photographic plates, with limitations as to quantitative accuracy," says Sheppard. "This was improved by the development of photoelectric recording during the war." Nevertheless, the Raman technique languished during the 1940s and 1950s, the period when IR spectroscopy was developing most rapidly. "Sensitivity remained poor," says Sheppard, "and fluorescence problems could occur from small amounts of impurity that absorbed in the visible and near-UV region."

This situation began to change in the early 1960s when lasers were introduced as Raman sources in place of conventional sources, such as mercury arcs. Laser excitation gave "another lease on life to Raman spectroscopy for commercial analysis," says Sheppard. Laser sources made it possible to obtain spectra with much higher signal-to-noise ratios, and the use of Raman spectroscopy expanded considerably when commercial laser-based instruments became available. Although Raman spectroscopy "is not yet as popular as IR spectroscopy," says retired chemistry professor Foil A. Miller of the University of Pittsburgh, "it is growing rapidly and is widely used for spot analysis of microsamples, polymer analysis, organic structure determination, and other applications."

Only time will tell what instrumental discoveries will emerge over the next 75 years. But it's certain that as instruments continue to advance, the frontiers of science will follow.

Chemical theory of the bond

During the past 75 years, chemists have sought to answer some very basic questions at the core of their science—questions such as "What is a bond?" and "How do atoms and molecules react?" Such questions have held a special fascination for theoretical chemists, who, about 75 years ago, began applying advanced mathematics, including quantum mechanics, in search of answers.

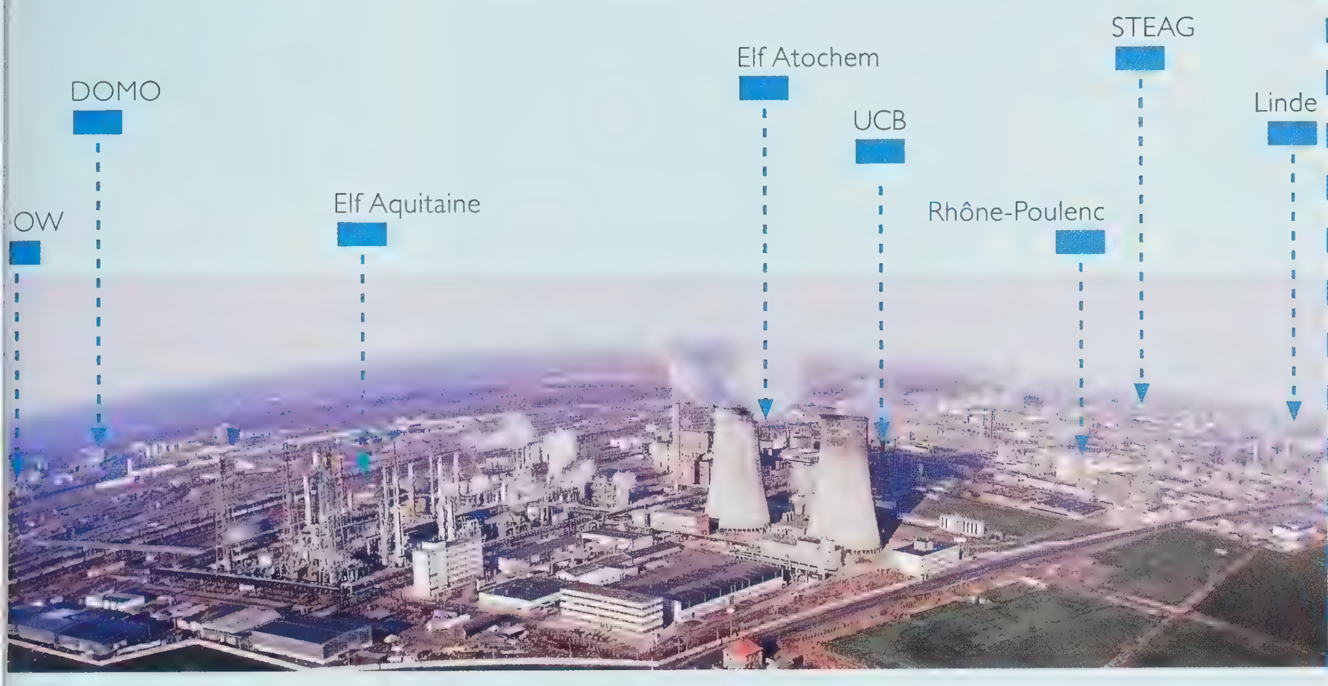
At the start of the 20th century, no one understood the force that held atoms together in a molecule, but there was little doubt that the force was electrical in nature. In 1904, for example, British physicist J. J. Thomson developed one of the first theories of valency involving the electron, the particle he had discovered just a few years earlier. Other theories followed—and faltered, because they could not explain the existence of both polar and nonpolar bonds.

In 1923, American chemist Gilbert N. Lewis published "Valence and the Structure of Atoms and Molecules." In this book, which has been described as his masterpiece, Lewis expounded on his idea, first published in 1916, that a pair of electrons shared by two atomic nuclei constitutes a covalent (single) bond.

Lewis' theory superseded all earlier theories and eventually won widespread acceptance. It was successful, in part, because it showed that polar and nonpolar

LEUNA

Investments



In the last decade, several internationally renowned companies, such as Elf Aquitaine (MIDER), Rhône-Poulenc, DOW Chemical (BSL), STEAG, Linde, DOMO and UCB have invested more than 9 billion DM in their plants in Leuna.

What is the reason for this?
Leuna is the production site for a wide variety of products ranging from chemical commodities to specialities. A site that has attracted medium-sized companies as well as large corporations. It offers a well-developed infrastructure, a large number of highly qualified specialists and has a long tradition in the production of chemicals. The economic attractiveness of industrial projects has vastly increased by the available subsidies. Companies established in Leuna can make use of the maximum subsidy rates available in Germany.

INFRALEUNA is the on-site infrastructure and service company. We are also active in marketing the site.

If you are interested in receiving more information about the chemical site in Leuna, please contact us:

INFRALEUNA
Dr. Sandro Amann · Site marketing
Am Haupttor
D-06236 Leuna · Germany
Tel. 0049-3461-43-6862 (Fax -3628)

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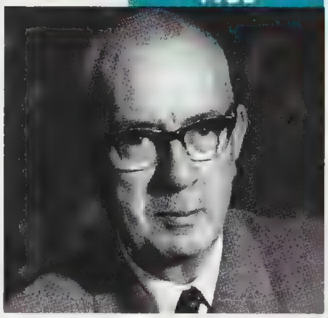
INFRALEUNA

INFRASTRUKTUR UND SERVICE GMBH

1953

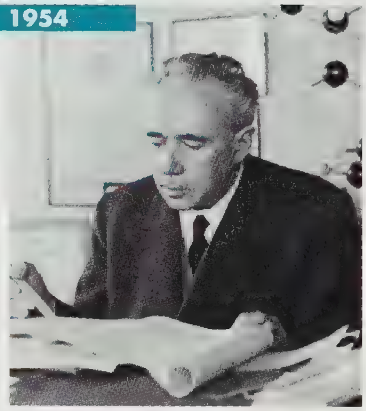
Frederick Sanger determines the first complete amino acid sequence of a protein.

1953



Karl Ziegler discovers catalyst for polymerizing ethylene at low temperature and pressure.

1954



Giulio Natta invents stereospecific polymerization of propylene.

bonds are not different kinds of bonds, but are situated at opposite ends of a continuum, depending on whether the electron pair of the bond is shared equally or not by the two atoms. One immediate result of the theory was that it settled the long-festering debate about the difference between strong and weak electrolytes.

Although Lewis' theory helped explain how atoms interact with one another to form molecules, the physical basis of both electron pairing and sharing remained "murky," according to historian John W. Servos in his book "Physical Chemistry from Ostwald to Pauling: The Making of a Science in America." Neither the Lewis theory nor its prime competitor—the planetary model of the atom developed by Danish physicist Niels H. D. Bohr in 1913—"was fully competent to explain the nature of the chemical bond or the structure of atoms and molecules," Servos writes.

But waiting in the wings was a theory, developed by physicists, that would soon be applied to chemical problems. Quantum theory was born in 1900 when Max Planck's analysis of blackbody radiation led to his insight that energy at the atomic level cannot be emitted or absorbed continuously, but only in small discrete steps called quanta.

Before the advent in 1913 of Bohr's atomic model, which was itself an outgrowth of quantum theory, chemists "rarely thought in terms of quanta," observes physical chemist Keith J. Laidler in his book "The World of Physical Chemistry." But by the mid-1920s, they could hardly avoid it. Theoretical physics was in ferment as a burst of new ideas from Wolfgang Pauli, Werner K. Heisenberg, Paul A. M. Dirac, Erwin Schrödinger, and others was shaping a revolutionary new understanding of the atom. In 1926, for example, Schrödinger, in his celebrated wave equation for the hydrogen atom, treated electrons as having the properties of waves and thus helped to move scientific discourse from electron orbits to electron wave functions and orbitals.

Quantum theory and its development as quantum mechanics in the 1920s "completely transformed our thinking about chemical problems," writes Laidler. Experimental results that previously were difficult to explain, such as spectra and photochemical reactions, could now be readily understood.

From this turbulent intellectual climate emerged two competing (and complementary) explanations of the chemical bond: the valence-bond (VB) theory and the molecular-orbital (MO) theory. These were the first quantum mechanical treatments of a chemical system.

Valence-bond theory

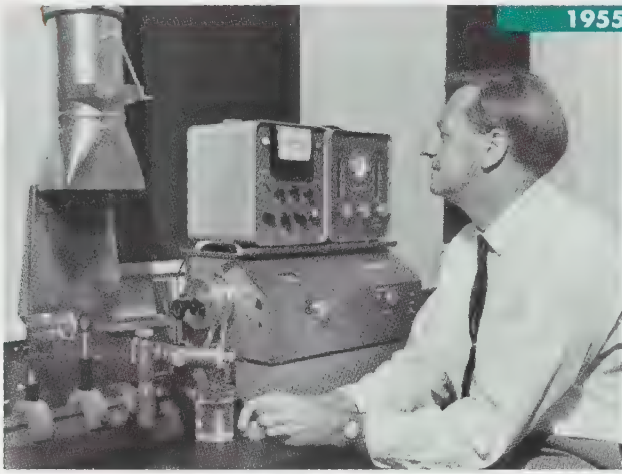
The VB approach was the brainchild of two young German physicists, Walter H. Heitler and Fritz W. London, who were working with Schrödinger at the University of Zurich. In a seminal paper written in 1927, they developed a wave equation for the hydrogen molecule with which it was possible to calculate approximate values of the molecule's ionization potential, heat of dissociation, and other constants. These predicted values were reasonably consistent with empirical values obtained by spectroscopic and chemical means. After their method was refined by other scientists, the fit between predictions and experimental data became "astonishingly close," Servos writes.

In a 1928 paper, London further refined the VB theory, making it, in essence, "a quantum mechanical version of Lewis' shared-pair theory," in Servos' words. Like Lewis, London assumed that the atoms forming the molecule retain their integrity and that valence bonds form from the pairing of two electrons of opposite spin. "And like Lewis, he equated the valence of an atom with its number of unpaired electrons; electrons already coupled with partners of opposite spin were chemically inert," Servos writes.

These ideas intrigued the young Linus Pauling, who, at the time, was in Europe on a postdoctoral Guggenheim Fellowship, soaking up as much quantum mechanics as he could from the big names in the field like Bohr and Schrödinger. Pauling befriended Heitler and London, and by the time he returned to the U.S. in the spring of 1928, he had become an enthusiastic advocate of their ideas. Not only did Pauling write about the Heitler-London approach in a manner to make it as appealing as possible to chemists, but he also began the crucial work of extending it to bonds in molecules more complex than H_2.

In this work, Pauling was able to use the VB approach to resolve the last major discrepancy remaining between the Bohr and Lewis views of the atom. That discrepancy involved the valences of the carbon atom. Neither model could account for the fact that carbon is usually quadrivalent, as in CH_4, but it also can be bivalent, as in CO. The bivalency could be

1955



Atomic absorption spectroscopy is proposed as a general analytical technique. In this 1965 photo, Alan Walsh works with a commercial AA spectrometer manufactured by Techtron.

1956

Courtesy of Wolf Foundation

Rudolph A. Marcus publishes the first papers describing his theory of electron-transfer reactions.

explained if carbon's four valence electrons were distributed in the ground state as follows: two paired electrons in the 2*s* orbital and one unpaired electron in each of two of the three 2*p* orbitals. However, if one of the 2*s* electrons is promoted to an empty 2*p* orbital, the atom could form four bonds to make CH_4, although one C–H bond (the one involving the 2*s* electron) would be different from the others, which is not the case.

Using London's theory of valence as his foundation, Pauling came up with a solution: He suggested that the 2*s* and 2*p* subshells can be mixed or hybridized to form four equivalent orbitals, each containing one unpaired electron. Thus, four shared-pair bonds could be formed, each one directed to one corner of a tetrahedron.

In a series of papers between 1931 and 1933, Pauling derived simple rules for the electron-pair bond and then demonstrated, according to Servos, "how these rules, in conjunction with a wide variety of experimental data, could be used to predict the structures, bond strengths, rotational motions, magnetic moments, and other properties of a wide variety of molecules and complex ions."

In these papers, published under the general title, "The Nature of the Chemical Bond," Pauling also developed his notion of resonance. In "his celebrated paper on benzene," Servos writes, he showed that "the energy and other properties of the molecule could not be explained in terms of the wave function of a single valence-bond structure, but instead were the product of a linear combination of the wave functions of several structures, each making a specifiable contribution to the properties of the whole. Like the elephant in the tale of the blind men, the benzene molecule did not correspond to any one of its many descriptions, but rather was captured by all of them."

Pauling's use of hybridization and resonance to explain both the tetrahedral carbon atom and the stable benzene ring "were triumphs of the new quantum chemistry," says Servos. The quantum mechanical treatment of bonds eventually was applied to "the ionic crystals of geochemistry, the intermetallic compounds of metallurgy, the coordination compounds of inorganic chemistry, and the polymers of biochemistry."

The molecular-orbital approach

The VB approach, which had been created in a single paper by Heitler and London, was soon in competition with the MO approach, which was born in 1928 in the work of Friedrich Hund and Robert S. Mulliken, two physicists who were close friends but who never published jointly. The MO approach treated the hydrogen molecule not as a composite of two atoms held together by valence bonds (as in the VB approach), but rather as a distinct entity in which the constituent atoms had lost their integrity, Servos writes. The advantages of the MO method over VB theory won it many adherents in the 1930s.

MO theory evolved over the years, enriched by contributions from many scientists. For example, the American physicist John C. Slater, who shares credit with Pauling for developing the idea of hybridization, also developed an approach that "brought the Hund-Mulliken method into better harmony with the Heitler-London-Pauling method," writes Mary Jo Nye in her book "Before Big Science: The Pursuit of Modern Chemistry and Physics, 1800–1940."

German theoretical physicist Erich Hückel also made important contributions to MO theory by applying it to benzene and other aromatic molecules. He suggested the idea of σ and π bonds, for example, and showed that benzene's stability arose from its six σ bonds in the plane of the ring and the "delocalized" cloud of six π electrons above and below the plane. Hückel also stated the famous rule that a closed ring with $(4n + 2)$ π electrons would be aromatic.

The MO approach also was used to gain a better understanding of molecular spectra, thanks to the pioneering work of spectroscopist Gerhard Herzberg, among others. In 1929, for example, Herzberg was the first to explain chemical bonding "in a simple and convincing manner in terms of bonding and antibonding electrons," says Laidler. "No contribution to the application of quantum mechanics to spectroscopy has been more important than [Herzberg's]."

Laidler points out that, at first, there was "considerable rivalry" between advocates of the VB and MO methods. Later, when the two methods were refined and improved, scientists realized that they converge and offer useful, complementary views of a molecule. For studies involving more complex molecules or the calculation of molecular properties, though, MO theory usually offers a significant advantage, says Stephen G. Brush, a historian of science at the University of Mary-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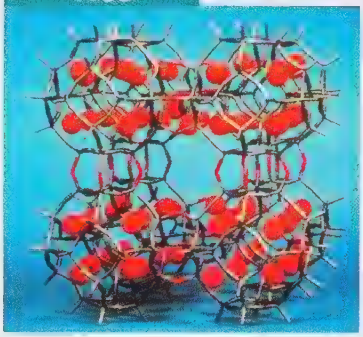
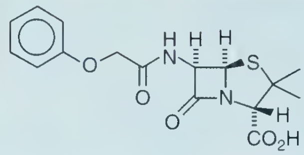
1956

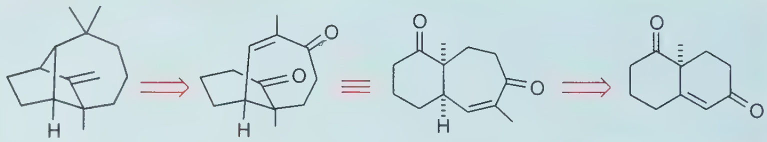


Union Carbide researchers publish the crystal structure of synthetic zeolite A.

1957



John C. Sheehan synthesizes penicillin V.



Longifolene

1961

E. J. Corey applies retrosynthetic strategy to synthesis of longifolene.

land, College Park. As that advantage became increasingly clear in the 1950s and '60s, chemists switched their allegiance from VB to MO. For example, the great success of Hückel's $4n + 2$ rule in predicting which molecules would be aromatic or nonaromatic convinced legions of organic chemists that MO theory was right, says Cornell University chemistry professor Roald Hoffmann.

The successes of MO theory when applied to chemical reactions also bolstered its popularity. For example, in 1952, Kenichi Fukui of Kyoto University introduced his "frontier orbital theory of reactions." He proposed that the course of a reaction is determined by the geometry and relative energies of the highest occupied molecular orbital of one reactant and the lowest unoccupied molecular orbital of the other. The theory explains that electrophilic attack, for example, will occur at the carbon atom having the greatest density of frontier (highest energy) electrons.

MO theory also gained luster from the work of American chemists Woodward and Hoffmann, who, between 1965 and 1969, formulated what have since become known as the Woodward-Hoffmann rules. These simple rules have been used very successfully to predict the course and stereochemistry of organic pericyclic reactions from the symmetry of the molecular orbitals in the excited and nonbonding states—an approach considered equivalent to Fukui's.

By the 1970s, "MO was definitely considered the more correct picture," Brush notes in a forthcoming article on the benzene problem. He also makes the interesting observation that "the success of Pauling's VB theory led chemists to accept quantum mechanics as a basis for chemical theory, and this [acceptance] in turn led them to *reject* VB because MO was a better way to use quantum mechanics."

Crystal and ligand field theories

While the VB and MO theories were harnessed to describe the bonding in both organic and inorganic compounds, a third quantum mechanical approach—crystal field theory—was developed specifically to deal with inorganic compounds, particularly coordination compounds. The foundation for this theory was laid by physicist Hans A. Bethe in Germany. In a classic 1929 paper, Bethe considered what happens to the energy levels of an isolated cation such as Na^+ when it is placed in the electrostatic field that exists within an ionic crystal such as NaCl. He showed how the strength of the field and the symmetry affect the cation's electronic levels.

In the 1930s, American physicist John H. Van Vleck at Harvard University and others applied the new theory to transition-metal complexes. They showed that the crystal field approach was valuable for modeling the behavior of *d* electrons in metal complexes and thus was very useful for understanding the colors, magnetic properties, and other characteristics of complexes. Crystal field theory, though, offers a purely ionic model, and so has little to say about bonding, particularly covalent bonding (including double bonding) between the metal ion and the ligand.

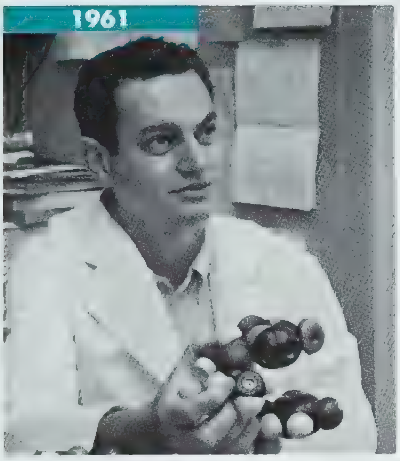
To get beyond the limitations of crystal field theory, scientists in the 1950s combined its best features with molecular-orbital concepts to produce ligand field theory, which has been called "the superior tool" for dealing with metal complexes. Ligand field theory is concerned with how the inner (nonbonding) orbitals of the central metal are split into different energy levels by the surrounding ligands. The power of the theory "to decipher the complicated stereochemistry of transition-metal complexes" was revealed by the University of Oxford's Leslie E. Orgel, one of the theory's key developers, at a conference of coordination chemists in 1950, writes William H. Brock in "The Norton History of Chemistry." Ligand field theory, Brock notes, "made a dramatic contribution to the renaissance of inorganic chemistry."

During the 1960s, the theory really took off, comments Derek A. Davenport, an emeritus professor of chemistry at Purdue University. In fact, Pauling's VB treatment of transition-metal complexes "got pretty well wiped out by ligand field theory," he says.

Quantum theory of chemical reactions

At the same time that quantum mechanics was transforming the way scientists viewed the covalent bond, it also was transforming the way they viewed the chemical reaction. A key person in both instances was London, the man who, with Heitler, had fashioned the first satisfactory quantum mechanical picture of the H_2 molecule. In 1928, London extended the Heitler-London approach to H_3, an unstable intermediate in the simplest three-atom exchange reaction, $H + H_2 \rightarrow H_2 + H$. In this reaction, an energy

NIH photo



Marshall W. Nirenberg—shown here with molecular models for RNA triplets—and Heinrich Matthaei decipher the first "word" of the genetic code.

R. Bruce Merrifield develops a method for solid-phase synthesis of polypeptides, opening the way to automated synthesis.

Roald Hoffmann, along with Robert B. Woodward, begins formulating rules for predicting the course and stereochemistry of organic pericyclic reactions.

Cornell University photo

barrier must be surmounted by the reactants as they are converted into products. London stated that all the properties of the energy barrier—height, location, and shape—are embodied in the quantum mechanical expression for the potential energy of the three-atom system.

Although London's equation involved extreme approximations, it became central to scientists' understanding of the transition state. The equation "was arrived at by an inspired process of groping," chemistry professor John C. Polanyi of the University of Toronto commented a few years ago. London published it without a derivation, but years later, according to Polanyi, other scientists "showed how one could derive it by subjecting the Schrödinger equation to life-threatening surgery." The special virtue of London's equation is that "it is composed of the same [mathematical] building blocks that describe the quantum nature of binding in the reagents and products," Polanyi noted.

In 1931, an important advance was made at the Kaiser Wilhelm Institute in Berlin by Michael Polanyi (John Polanyi's father) and Henry Eyring, who was then a postdoctoral fellow. Melding London's equation with experimental data, they constructed the first potential energy surface for a reaction—specifically, the exchange reaction between H and H_2.

A potential energy surface is a topographic road map useful for visualizing a reaction because it shows the potential energy of the system as a function of the relative positions of all the atoms taking part in the reaction. As reactants evolve into products, the molecules migrate from one valley (low-energy state), over a "mountain pass" or saddle point, into another valley. The saddle point can be defined as the transition state—the intermediate stage from which the reaction proceeds irreversibly to products.

A theory describing this transition state was published in 1935 by Eyring, then at Princeton University, and independently by Michael Polanyi and Meredith G. Evans at the University of Manchester, England. According to Laidler, the essence of their theory is that species close to the saddle point—the so-called activated complexes—are "in a state of quasi-equilibrium with the reactants, so that their concentration can be calculated. The rate of reaction is then the concentration of these complexes multiplied by the frequency with which they are converted into products."

In a 1983 article reviewing the development of transition-state theory, Laidler and M. Christine King, an Ottawa colleague, described the three essential features of the theory, pointing out that not one of them was completely new. "The genius of the 1935 work," they wrote, "was in putting these three features together and arriving at a simple but general rate equation. In addition, Eyring made a very important and novel contribution in appreciating the great significance of the reaction coordinate," the path the reaction takes along the potential energy surface.

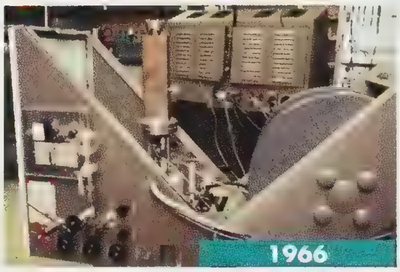
According to Laidler and King's article, transition-state theory ran into "a good deal of opposition in its early stages," for several reasons. The first papers were hard to follow and took "very bold—some would say reckless—steps, and it was predictable that many would fail to understand their arguments."

Eventually, though, the theory's value for providing qualitative insight into chemical reaction rates became widely appreciated, even though it was less successful in its original goal—the calculation of absolute reaction rates. In 1962, British chemistry Nobelist George Porter, who made important contributions to the study of very fast reactions, wrote that transition-state theory, since its inception, "has provided the basis of chemical kinetic theory; imperfect as it may be, it is undoubtedly the most useful theory that we possess." Its greatest success, he said, has been "in providing a framework in terms of which even the most complicated reactions can be better understood."

It took about half a century for experiment to catch up with transition-state theory. In 1980, John Polanyi's group succeeded in obtaining spectroscopic evidence for transition species (in the reaction of a fluorine atom with Na_2). And in 1987, using femtosecond laser techniques, Zewail's group at Caltech was able to directly observe transition-state structures during bond breaking (in the reaction $ICN \rightarrow I + CN$) and during bond making (in the reaction $H + CO_2 \rightarrow OH + CO$).

Electron-transfer reactions

Transition-state theory did much in its early years to shed light on reactions involving the formation or cleavage of bonds. But it could not be applied to perhaps the most elementary type of reaction in chemistry—the hopping of an electron from one atomic ion to another—because there was no way to take into account the involvement of the surrounding solvent molecules. It fell to



Ion-cyclotron resonance mass spectrometer is developed.

FT-NMR spectroscopy is developed. Here, chemist Richard Ernst of Varian Associates transfers FT-NMR data to punch cards.

Stanford University photo

Paul Berg uses enzymes to cut and splice pieces of DNA to form the first recombinant DNA.

Caltech chemistry professor Rudolph A. Marcus to figure out a way to characterize the transition state for such an electron-transfer reaction.

Marcus, who happens to have been born the same year as C&EN, became interested in electrostatics in the early 1950s—early in his research career. The study of electron-transfer rates was already very active at the time, and scientists had determined that electron transfer between small ions such as ferric and ferrous ions is relatively slow, whereas electron transfer between larger ions is faster. Chemist Willard F. Libby, then at the University of Chicago, had published an electrostatic calculation that purported to explain this observation by invoking the Franck-Condon principle: Since the orientation of solvent molecules around Fe^{2+} and Fe^{3+} is quite different, Libby reasoned, when the electron jumps from Fe^{2+} to Fe^{3+}, the solvent environment around each ion is suddenly the wrong one because the solvent molecules can't rearrange themselves as fast as the electron jumps. The smaller the reactant, Libby proposed, the more inappropriate its environment becomes.

When Marcus came across Libby's paper in 1955 and studied it, he sensed that something about Libby's explanation was "not quite right," but he wasn't sure at first what it was. Within a month, though, Marcus realized that although Libby's use of the Franck-Condon principle was clever, the way it was implemented violated the law of conservation of energy. Marcus also realized that he had to find a way to calculate the free energy of formation of fluctuations in the interatomic distances and orientation of the solvent molecules around the ions in solution so as to allow the system to reach a transition state that satisfied the Franck-Condon principle. Marcus succeeded in carrying out this calculation, and from the result, he was able to characterize the transition state for the reaction and calculate the reaction rate constant itself.

Obtaining these results was "one of the most thrilling moments of my scientific life," Marcus wrote many years later. He published the results in two papers in 1956. Then, over the next nine years, he further developed the "Marcus theory," extending his original concept to include intramolecular vibrational effects, electrochemical electron-transfer reactions, and related processes.

The theory made numerous predictions, and experiments confirmed many of them almost immediately. However, one of the theory's more surprising predictions—that beyond a certain point, electron-transfer rates would decrease with increasing driving force—took 25 years to be verified experimentally. The theory is now being applied in areas such as photosynthesis, electrically conducting polymers, chemiluminescence, and corrosion.

Although quantum mechanics clearly has revolutionized chemistry, it "did not have the overwhelming effect on chemical research that some theoretical physicists predicted," Laidler wrote in a 1990 article. "Dirac, for example, believed at one time that with the introduction of quantum mechanics, all chemical problems were solved, since everything could be done by setting up and solving the appropriate quantum mechanical equations; there would be no need for further experimental work."

In fact, Laidler pointed out, "things have not worked out that way." In the real world, the equations are almost always too complicated to solve exactly. "We are forced to make many approximations, and it is hard to know which to make." Chemists must continue to rely on experiments and simple approximate theories, "and it seems likely that this will always be the case."

What has changed in the past 75 years, though, is that theoretical chemistry has come into its own as a sophisticated and useful tool. As Caltech chemistry professor William A. Goddard III put it in a 1985 article, "Theorists are now in a position to tackle many important chemical, biological, and materials problems on an equal footing with experimentalists."

Chemistry meets biology

The interface between chemistry and biology has been one of the most fertile areas of both disciplines during the past 75 years. In a sense, chemistry has "met" biology in the years since 1923, as chemists and their tools have gained the ability to study molecular systems of life-sized complexity. At the same time, biologists have begun to be able to dissect living systems down to the level of interactions between molecules, spawning in the process the very concept of "molecular" biology.

When C&EN was first published, chemists were vigorously debating the idea, proposed about 1920 by German chemist Hermann Staudinger, that molecules could form enormously long chains that Staudinger called macromolecules. Chemical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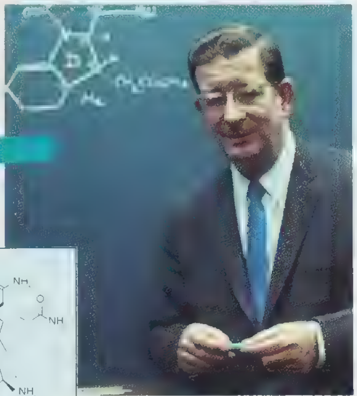
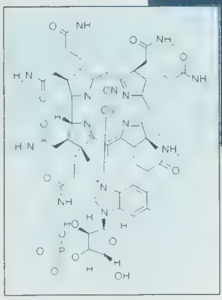
1973





Formal synthesis of vitamin B-12 is achieved by Robert B. Woodward (above) and Albert Eschenmoser.

1974

F. Sherwood Rowland (left) and Mario Molina propose the theory of chlorine-catalyzed ozone depletion.

1980

John Polanyi's group obtains spectroscopic evidence for transition species.

historian Thackray calls Staudinger's proposal the most important concept in the chemical sciences in the 20th century, providing the theoretical foundation for both polymer science and biotechnology. "It has, is, and will transform our lives, even to transforming the very idea of what life is," Thackray says. "In the world we now live in, 70 to 80% of what's interesting consists of huge molecules."

In Staudinger's day, many important biological substances were thought to be gelatinous colloids, "sticky messes that you couldn't crystallize," Thackray calls them. Invention of the ultracentrifuge around 1923 by Swedish biochemist The Svedberg provided a way to determine the size and homogeneity of these substances without crystallizing them. By the mid-1930s, Svedberg and others had used the ultracentrifuge to purify a variety of proteins, showing that they were substances with uniform—and huge—molecular weights ranging in this early work from 17,200 for myoglobin to nearly 7 million for snail hemocyanin.

Early pioneers were also beginning to crystallize proteins: In 1926, James B. Sumner crystallized urease, a protein that could catalyze the decomposition of urea. J. D. Bernal and Dorothy Crowfoot (later Hodgkin) at Cambridge University recorded the X-ray diffraction pattern for crystalline pepsin in 1934, revealing an orderly, structured, but dauntingly complex molecule. It would be another 25 years before Max F. Perutz and John C. Kendrew, from the same laboratory, would be able to solve the structure of a protein by deciphering its X-ray diffraction pattern.

This early work, done without computers, was painfully slow. Researchers calculated power series and Fourier transforms by hand. Crowfoot herself, for example, recorded the X-ray diffraction pattern of crystalline insulin in 1935 but didn't solve its structure until 1969.

Pauling became attracted to the field in the mid-1930s. By the end of the decade, he and Caltech colleague Robert Corey were pinning down bond lengths and angles in amino acids and small peptides based on X-ray crystal data and beginning to use this information to predict protein structure. The peptide bond is rigid and planar, they found, but other bonds are more flexible, allowing amino acids to form hydrogen bonds with one another. By the early 1950s, their calculations predicted two repeating structures that amino acid chains in proteins were likely to assume—the α-helix and the β-pleated sheet.

Biochemists understood before 1923 that proteins had something to do with biocatalysis, but whether the protein itself was catalytic or just held within it a much smaller molecular catalyst was an open debate. By crystallizing urease and demonstrating that this enzyme was a protein, Sumner helped establish that proteins alone can be catalytic. A decade later, John H. Northrop, working with crystalline pepsin, trypsin, and chymotrypsin, made the case even more solidly by showing that the protein content of these three digestive enzymes correlated directly with their catalytic activity. These and other early experiments established that "like garden variety chemicals, the molecules responsible for biological catalysis would crystallize in the test tube," says MIT bioinorganic chemist Stephen J. Lippard. By 1960, about 75 enzymes had been crystallized, all of them proteins, although many also contained non-protein prosthetic groups that were critical to their catalytic activity.

DNA structure

Scientists were slower to realize that nucleic acids also form long-chain macromolecules of biological importance. In retrospect, the connection between these molecules and heredity seems obvious—19th-century biochemists knew, for example, that the heads of sperm contain almost nothing except nucleic acid. But the molecules seemed too "boring" to be genetically important. There are only four nucleotides in DNA—compared with 20 amino acids in proteins—and, by the analytical sensitivity of the 1920s, all four appeared to be present in exact stoichiometric equivalence, making every piece of DNA seem identical to every other one.

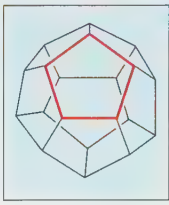
The picture changed in 1944 when Oswald T. Avery and his colleagues showed that a cell extract containing only DNA could transmit a new trait to a bacterium that would be inherited by subsequent generations. Shortly afterward, more sensitive analytical techniques enabled Erwin Chargaff to show how genetic information could be stored in DNA. The nucleic acids in DNA form pairs, he found, and, although the concentration of one partner in the pair always matches that of the other one, the relative amounts of the two pairs vary when the DNA comes from different sources.

These findings set the stage for the 1953 discovery of the double-helical structure of DNA by James D. Watson and Fran-

1982

A new class of aluminophosphate molecular sieves is discovered by Edith Flanigen and coworkers at Union Carbide.

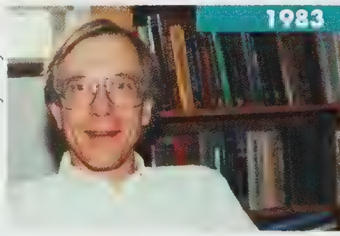
Photo by Tom Sobolik, Black Star, courtesy of Union Carbide



1982

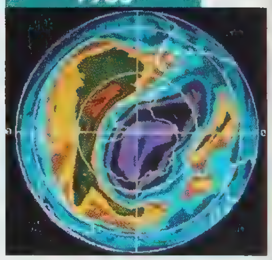
Leo A. Paquette synthesizes dodecahedrane.

Photo by Rudy Baum



1983

Thomas R. Cech shows that RNA can be a biocatalyst. Sidney Altman makes the same discovery independently.



1985

Antarctic ozone hole is discovered.

NASA photo

cis H. C. Crick. Their now-famous model in which paired bases form hydrogen-bonded steps in a molecular spiral staircase is undoubtedly one of the best known scientific discoveries of the century. As Crick himself wrote decades later, the DNA double helix captured the imagination of both scientists and the public, in part because the structure itself has such style and intrinsic beauty. It's important, as well, because it conceptually forms the bridge between chemistry and biology. The Watson-Crick model of DNA revealed genes as chemical entities that could—at least hypothetically—be analyzed, understood, and possibly changed using the tools of chemistry.

Using the DNA structure as a platform, many biochemists in the 1950s and '60s isolated the enzymes that control DNA metabolism, from its self-replicating synthesis to its role as the template for producing messenger RNA, which, in turn, determines the sequence of amino acids in protein chains. This sequence is specified by a "code" of consecutive base triplets of RNA, which was deciphered throughout the 1960s by Marshall W. Nirenberg and his colleagues at the National Institutes of Health. The code is a nearly universal one, they found, so that a piece of DNA from a human cell, for example, inserted into a bacterium will direct that cell's machinery to make the same protein that the human cell would make.

Among the enzymes involved in DNA metabolism, the restriction endonucleases form a class of particular practical importance. These molecules break the DNA chain at very specific locations. Among other uses, they have become tools to break down huge DNA molecules into manageable fragments to learn their sequences. In 1972, Paul Berg at Stanford University used a restriction endonuclease to cut DNA and then pasted two cut strands together with the aid of another enzyme, a ligase, to form a circular hybrid molecule, a recombinant DNA. The following year, Stanley Cohen, also at Stanford, and Herbert Boyer at the University of California, San Francisco, took the work further by splicing together pieces of viral and bacterial DNA that conferred specific traits—resistance to two antibiotics—and inserting this hybrid DNA into bacteria. In the process, they transferred the antibiotic resistance to the bacteria and produced a recombinant DNA organism.

The commercial potential of such recombinant organisms led almost immediately to the founding of several small companies and of a new field—biotechnology. Boyer helped to found Genentech in 1976; a year earlier Cohen had become a director of Cetus, an existing pharmaceutical company that refocused its attention toward exploiting the potential of biotechnology; and Biogen, another important early company in biotechnology, was founded in 1977.

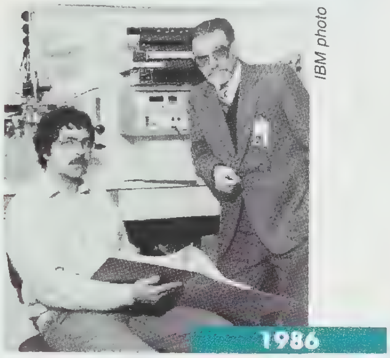
Meanwhile, researchers were also developing much more rapid methods to first determine the sequence of and then synthesize biological macromolecules. In 1945, Frederick Sanger at Cambridge University developed a way of attaching a dye molecule to the terminal amino group of a protein that allowed the labeled amino acid residue to be identified chromatographically after the protein had been partially degraded. Using this procedure and various cleaving agents, Sanger determined the first complete amino acid sequence of a protein, bovine insulin, in 1953. At about the same time, Swedish chemist Pehr Edman used phenyl isothiocyanate to remove only the terminal amino acid in a protein chain, opening the way to an automated method of degradation. Sanger later turned his attention to determining DNA sequences, developing a method to do so in the late 1970s that also could be automated.

Genes and proteins are such huge molecules that the practical way to determine their sequence is to first break them into manageable pieces, determine the sequence of each piece, and then combine this information to reconstruct the entire sequence of the original macromolecule. Keeping track of all this information and reassembling it correctly requires the high-speed, high-capacity computers that were being developed independently during the 1960s and '70s.

Advances in automated sequencing of biological macromolecules continued so rapidly during the 1980s that by the end of the decade, researchers were planning what Thackray calls "the final, ultimate mechanization of chemical analysis"—an international effort to sequence all 3 billion bases in human DNA. Known as the Human Genome Project, the program officially got under way in 1990. Currently about halfway through its expected 15-year lifetime, the program involves researchers from more than 50 countries. Built into the project's design is an expectation that sequencing methods will continue to become both more rapid and less expensive.

Robert F. Curl Jr. (standing) and, from left, Sean C. O'Brien, Richard E. Smalley, Harold W. Kroto, and James R. Heath discover buckminsterfullerene.

J. Georg Bednorz (seated) and K. Alex Müller discover copper oxides that become superconducting at high temperatures.



IBM photo

Photo by Rudy Baum

The first direct observations of chemical events (bond making and bond breaking) in real time are made with femtosecond lasers by Ahmed H. Zewail and coworkers at Caltech.

Biochemists were able to synthesize peptide bonds long before 1923, thanks principally to the work of Emil Fischer in the late 19th century. But Fischer's synthesis was laborious, and its yield, when applied to large macromolecules, was infinitesimal. As Thackray points out: "When you are dealing with tens of thousands or hundreds of thousands of atoms, it's no good having someone at the bench doing the synthesis one peptide bond at a time. You've got to find some more automated way."

The route to automation opened up in the late 1950s and early '60s when R. Bruce Merrifield of Rockefeller University developed a solid-phase method to synthesize polypeptides. Merrifield attached the first amino acid of a polypeptide to a solid polymer. Each synthetic cycle added another amino acid to the peptide chain growing from the polymer, while leaving by-products and unreacted starting materials in a liquid phase that could be washed away. A similar approach was quickly applied to the synthesis of nucleic acid macromolecules.

In the 1960s, Merrifield was able to synthesize a nine-residue peptide with an 85% yield. Steady technical improvements have boosted yields, allowing the synthesis of longer peptide chains. In 1992, for example, Stephen Kent used solid-phase synthesis to make a protein that has 99 amino acids, HIV protease. Even so, the method is generally used only to make relatively small polypeptides or ones containing nonnatural amino acids. The most widely used technique for making larger proteins or any protein on a large scale has become molecular cloning based on recombinant DNA technology.

In the 1970s, Michael Smith at the University of British Columbia worked out a technique called site-directed mutagenesis that allows researchers to harness the cell's protein-synthesizing machinery while changing single amino acids in proteins at specific locations. The technique has become a fundamental tool for studying the relationship between structure and function in proteins and for tailoring the properties of proteins.

In 1985, Kary B. Mullis and coworkers at Cetus devised a technique to amplify relatively small segments of DNA over and over so that millions of copies can be produced in a few hours. The technique, called the polymerase chain reaction, uses chemically synthesized DNA fragments to prime a bacterial enzyme, DNA polymerase, to copy the desired portion of a DNA strand. The original DNA and the new copy then serve as templates for another round of polymerase-directed synthesis, leading to an exponential amplification of the original DNA segment.

Biochemical pathways

Macromolecules are not the only molecules at the interface of chemistry and biology, and C&EN's first decades were a period of important discoveries on a number of other fronts as well. For example, many of the basic pathways for the chemical processes going on in cells were mapped out during this period.

In the early 1930s, German biochemists Hans A. Krebs and Kurt Henseleit, studying the formation of urea in slices of rat liver, found that catalytic amounts of certain amino acids could greatly increase urea production. They proposed a catalytic cycle in which urea is formed from ammonia and aspartate with three amino acids as intermediates. Five years later, Krebs carried the idea of metabolic cycles a major step further when he pulled together work on the metabolic breakdown of carbohydrates and the biological reduction of oxygen to carbon dioxide into an elaborate cycle of reactions often still referred to as the Krebs cycle.

Many of the early studies of metabolic pathways were done by identifying agents that could block metabolism, and then measuring what molecules accumulated when these blocking agents were administered to living animals. The advent of radioactive isotopes provided a way to identify much smaller amounts of metabolic intermediates and to trace individual atoms as they moved through the steps of normal metabolism.

George C. de Hevesy at the University of Freiburg, Germany, used radioactive thorium to study the transport of lead in bean plants in 1923. When de Hevesy's colleague Rudolf Schoenheimer was forced from Germany by the Nazi government in 1933, he fled to Columbia University, where Harold C. Urey had discovered deuterium the year before. For the remainder of the decade, Schoenheimer worked out methods to introduce first deuterium (which is not radioactive) and later other isotopes at specific locations in fatty acids and amino acids, which he then fed to animals to determine how these molecules are metabolized.

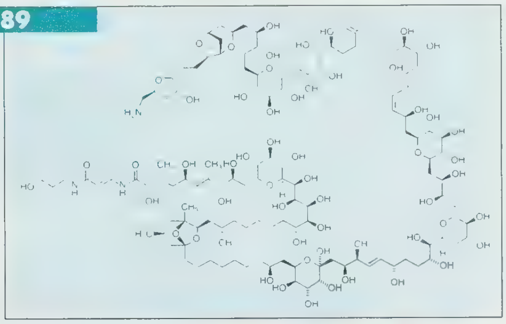
At the end of World War II, the long-lived radioisotopes ^{14}C and ^{3}H became available for investigating biochemical pathways, ushering in what medical his-

Texas Center for Superconductivity photo

1987

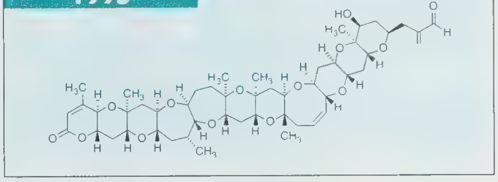
Paul C. W. Chu finds the first high-temperature superconductor that needs to be cooled only to liquid nitrogen temperatures.

1989



Yoshito Kishi synthesizes palytoxin.

1995



K. C. Nicolaou synthesizes brevetoxin B.

torian Frederic L. Holmes calls "the golden age of laying down all the metabolic pathways. The whole metabolic map fell together rather rapidly in the immediate post-war period."

For example, Melvin Calvin and his colleagues at the University of California, Berkeley, exposed photosynthetic algae to $^{14}CO_2$ and used the newly developed analytical technique of two-dimensional paper chromatography to separate the radioactive compounds that formed either in the dark or after different periods of exposure to light. Photosynthesis has two distinct parts, they found, and its light-gathering, chlorophyll-dependent steps do not involve CO_2 at all. By 1956, they had traced the pathway by which carbon from CO_2 is incorporated, via glyceraldehyde-3-phosphate, into carbohydrates and other biomolecules.

After the 1950s, the focus in metabolic studies shifted from unraveling basic pathways to understanding how the processes are controlled, usually by enzymes. In fact, by mid-century, all roads—whether structural analysis, nucleic acid synthesis, or metabolic studies—seemed to lead to enzymes and their role as biocatalysts. "Understanding proteins as enzymes is the number one thing that biologically oriented chemists have tried to do over the past 75 years," says MIT's Lippard. That effort still dominates the field. "Much of what we know and what we do as chemists in biology is to try to understand the details of enzyme catalysis," says Harvard's Whitesides.

Origins of life

In the 1920s, biochemists began to seriously consider how living systems might have first evolved on prebiotic Earth. In that decade, Russian biochemist Alexander I. Oparin and British biochemist John B. S. Haldane independently suggested that simple organic molecules are difficult to transform into the more complex ones found in living systems in an oxygen-rich atmosphere such as the one now found on Earth. However, they argued, a world without photosynthesizing plants might well have a hydrogen-rich, reducing atmosphere in which such reactions would occur more easily.

These ideas were slow to take hold, but in 1953, Stanley L. Miller and Urey, by then at the University of Chicago, experimentally re-created a mixture of hydrogen, methane, ammonia, and water that mimicked the prebiotic atmosphere of Earth. When the mixture was exposed to an electrical discharge to simulate lightning, 10% of the carbon was converted into a rich mixture of aldehydes and carboxylic and amino acids. Later experiments by Miller and others found that, by slightly varying the reaction mix, they could generate more than half of the amino acids found in proteins as well as adenine and other nucleic acid bases.

The rich complexity of interactions between nucleic acids and proteins unraveled during the 1960s raised the question of whether either polymer could have preceded the other one in the evolution of life. Toward the end of the decade, several researchers independently hypothesized that RNA seemed the most likely initial biopolymer. They proposed that modern life, based on interactions between DNA, RNA, and proteins, might have evolved from an earlier RNA world.

This hypothesis received a substantial boost in 1983 when Thomas R. Cech and Sidney Altman independently discovered that some reactions in contemporary biology are catalyzed by RNA. The first reactions to be identified were self-splicing reactions in bacteria in which strands of RNA catalyze the removal of an extraneous section from the middle of the polymer. More recently, RNAs have been synthesized that can join together oligonucleotides using ATP as an energy source.

The RNA-world hypothesis is a work-in-progress. Though it has many adherents, several key steps in the process have yet to be explained, such as why both proteins and nucleic acid polymers are made exclusively of L-isomers when the Miller-Urey experiment and others like it generate their products as racemic mixtures. Recent work also suggests that Earth's atmosphere may never have been as reducing as the one simulated by Miller and Urey and that the organic synthesis they observed would have been much more difficult—or even impossible—under real-Earth conditions.

The idea of an RNA world as an interim step to life as it now exists on Earth is only one of many chemical ideas that stand today in about the same state of uncertainty that Staudinger's theory of macromolecules did in 1923. As chemical historian Thackray points out, "Concepts that we now take as self-evident were once at least debatable, if not clearly ridiculous." Which of these current proposals is to become the foundation of the next stage of our understanding of chemistry will become clear sometime in the next 75 years.◀

From Coal Tar To Crafting A Wealth Of Diversity

Shaped in part by the demands and spoils of war and in part by boundless ingenuity and entrepreneurial spirit, the chemical industry has changed the face of the world

Marc S. Reisch
C&EN Northeast News Bureau

A history of the chemical enterprise over the 75-year period from 1923 to 1998 doesn't begin with a single cataclysmic event or the birth of a specific company. Nor does it progress to a satisfying, tie-up-the-loose-ends conclusion.

Actually, this history can have no beginning, because the story of modern chemistry begins with Joseph Priestley, the 18th-century discoverer of oxygen, and his contemporary, Antoine-Laurent Lavoisier, who devised the modern method of chemical nomenclature. And this history cannot have an end, because the chemical enterprise is still vital and growing.

That said, it is obvious that the chemical enterprise has become a vastly more complex undertaking than it was in 1923, when "the chemical industry" was a handful of companies that made organic compounds and marketed them to users such as textile makers, pharmaceutical manufacturers, and explosives producers. A chronicle of events and people who made the industry what it is today, and of the people who financed the growth of the chemical enterprise, shows that "the journey, not the arrival, matters," as English editor Leonard Woolf observed about his own life.

Some of the more important raw materials for the journey of the last 75 years are coal, oil, gas, acetylene, sulfur, brine, and biomass. Each material has had greater or lesser importance depending on the knowledge available to use it, the technology in place to transform it, and the economics involved in its transformation, transportation, and use.

The raw materials have always existed. But it took an industrial revolution to get at the raw material, and then it took genius to develop technology to transform the dross of raw materials into the gold of refined fuels, chemical products, and medicines.

Modern-day alchemists were not interested in changing base metal into gold, but they were interested in changing base substances such as coal or petroleum into the stuff of life and death—including explosives for war, mining, and construction; plastics for airplane windshields, buttons, and toys; medicines to cure the wounded or the ailing; textile dyes to add color to business suits, cocktail party dresses, or military uniforms; and fertilizers to increase food production for an army or a nation.

Among the modern-day alchemists who applied their genius to newly available raw materials were nylon's inventor, Wallace Carothers; Ralph Landau, a chemical engineer who developed breakthrough processes in the manufacture of ethylene oxide, ethylene glycol, and *p*-xylene; Eugene Houdry, originator of petroleum cracking catalyst technology; Carl Bosch, developer of high-pressure chemical technology and later chairman of BASF; and Guilio Natta, of the Milan Polytechnic Institute, who developed polypropylene plastics technology.

It also took the organizational prowess and talent of industrialists to finance and then commercialize the advances of these chemists before and during the past 75 years. They include such people as George Eastman, who formed Eastman Kodak and Eastman Chemical; Franklin Olin, who started a munitions business now known as Olin Corp.; Carl Duisberg, who organized the I. G. Farben cartel in Germany in 1925; John F. Queeny, who formed Monsanto; Herbert Dow, who fashioned Dow Chemical; and Pierre DuPont, who transformed the premiere U.S. explosives maker, E. I. DuPont de Nemours, into the diversified chemical maker so well known today.

When this century was still young and C&EN was an infant, Europe especially, as well as the U.S. and Canada, had recently suffered through the bruising Great War of 1914–18 that killed 8.5 million and wounded 21 million people. The chemical industry had played its part in providing war materials, largely based on coal-derived chemicals. For instance, coal tar provided a source for synthetic dyes; coal coking furnaces provided the nitrogen for fertilizers and trinitrotoluene (TNT) explosives, and it also provided the toluene for those explosives.

These coal-derived chemicals were a by-product of the Industrial Revolution, which in Great Britain began in the late-18th century. Coal in Britain and subsequently in many other countries provided the energy and steam to run the railroad locomotives and steamships of the early-19th century, and it provided the energy to heat homes.

The destructive distillation of this versatile mineral also produced a gas to light the street lamps of early-20th-century city dwellers. And the process of heating coal to make coke—a raw material in the manufacture of high-carbon steel—also produces a number of chemically useful gases and by-products: coal tar, ammonia, and benzene. The distillation and refinement of these raw materials were the basis of a growing synthetic organic chemical industry, particularly in Britain, Germany, and in the U.S. at the turn of the century.

A capsule chronology

Coal was and still is an abundant raw material. It still represents nearly 75% of the world's total proven fossil fuel reserves. But beginning in the 1920s, petro-

1920s

Monsanto's "modern" packaging for saccharin, the company's first product.

1920s

DuPont enters the chemical fibers business with this Buffalo, N.Y., rayon plant, shown here under construction in 1920.

leum producers and chemical manufacturers began to establish in-house research units to learn how to use petroleum and natural gas as a less expensive source for organic raw materials than coal. However, when the first News Edition of *Industrial & Engineering Chemistry* saw the light of day in 1923, coal was the engine of chemical industry growth.

The world depression of the 1930s did not significantly slow the development of the petrochemical industry. Union Carbide and the U.S. arm of Anglo-Dutch Royal Dutch/Shell led development of novel chemicals from petroleum distillates. But it was World War II starting in Europe and then spreading to Africa and Asia in the late thirties until its conclusion in 1945 that accounted for more than the development of advanced catalytic cracking of petroleum for fuel. The war also led to the large-scale manufacture of synthetic rubber, large-scale commercial production of wonder drugs such as penicillin, and the widespread substitution of natural fibers by synthetic fibers such as nylon.

With the end of World War II, production in the U.S. devoted to winning the war went to satisfying pent-up consumer demand for housing, appliances, and textile goods. During the 1950s, war-torn European chemical producers rebuilt their factories and began a new era of commercial development based on economical petroleum- and natural-gas-derived chemicals. The decade also saw the widespread introduction of new thermoplastics such as acrylic, polystyrene, polyethylene, and polypropylene into consumer markets.

In the 1960s, polymers accounted for more than half of the total production of U.S. chemical manufacturers. Industry overcapacity and product saturation in many markets lowered profits for most chemical producers. In response, many sought to diversify by integrating forward into consumer products, developing niches in specialty chemicals, or diversifying into related agricultural and pharmaceutical products.

During the 1970s, U.S. chemical makers were losing their textile dyes businesses to better integrated European producers. World chemical manufacturers also began a period of retrenchment, hurt first by the Arab oil embargo of 1973-74, which drove up energy and raw material prices, then by the growing government attention to industry's pollution of the environment.

Increasing competition because of overcapacity forced a number of U.S. producers to restructure their businesses in the 1980s and allowed European producers to buy a larger position in the U.S. market. In 1984, the accidental release of methyl isocyanate gas at Union Carbide's pesticide plant in Bhopal, India, made the industry rethink its production methods. And although environmental legislation hobbled or forced change for some chemical producers, the Bhopal incident provided further incentive to develop new chemical process routes in biotechnology for both pharmaceutical and agricultural applications.

U.S. producers were in good competitive shape to expand globally in the 1990s. Large European chemical producers began their own period of restructuring burdened by the high costs of labor in their home markets. Asian chemical producers that had built capacity in petrochemicals and fiber in the '80s became significant global competitors. All producers sought opportunities globally in this decade to take advantage of opportunities in Eastern Europe following the collapse of the Soviet Union and in newly industrialized Asian markets.

Dyes spur U.S. industry growth

By the early 1920s, the U.S. chemical enterprise had in large part made up for chemical privations that World War I had caused. A British blockade had effectively cut off U.S.-based textile industries from the textile dyes primarily imported from Germany. By the end of the war, many U.S. producers supplied textile dyes to U.S. mills, and U.S. manufacturers had also managed to supply many of the pharmaceuticals previously imported from the more advanced German chemical industry as well.

U.S. firms were still not able to produce dyes, pharmaceuticals, fertilizers, and other chemical materials as economically as German companies such as Bayer, Hoechst, Badische Anilin & Soda Fabrik (BASF), Kalle, and Cassella. The German university system, government support, and the commercial enterprise of German industrialists made those companies formidable competitors.

U.S. chemical companies got their start in some cases from technology imported from German partners—and expropriated from German competitors by the U.S. government after World War I, then sold to U.S. chemical companies. In this way, Bay-

One of the first U.S. petrochemical plants is operated in Clendenin, W.Va., by Union Carbide.

1920s

1920s

A Rohm and Haas production facility for Amberol, a synthetic resin used to manufacture varnish.

er not only lost its hold on the U.S. aspirin market but also lost its name to Sterling Drugs. (Bayer recovered the U.S. rights to the Bayer name and the right to market Bayer aspirin in 1994 when it bought the assets of Sterling Winthrop from SmithKline Beecham for $1 billion.)

After hostilities ended when the U.S. and its Allies signed an armistice with Germany in November 1918, Germany's chemical companies moved to protect their advanced technology and rebuild their markets. However, in many cases they were forced to reveal to the victorious Allies what had been until then proprietary process technology, such as the Haber-Bosch ammonia technology.

U.S. chemical industry executives worked hard to establish the industry. They worked for the passage of protective tariffs, secured patent positions formerly held by their largest competitors—German chemical companies—and established their own research positions starting with work on the German patents newly available to them. A few also began research work based on petroleum feedstocks.

These executives succeeded in securing protection against low-cost imports first with the Fordney-McCumber Tariff Act of 1922 and later with the Smoot-Hawley Tariff Act of 1930, which placed high tariffs on dyes imported into the U.S. Tariffs were based on the U.S. selling price rather than on the selling price of the item in its country of origin. This resulted in a much higher duty on imported dyes and helped U.S. dye makers maintain higher prices.

This tariff system lasted until the late 1960s, when the U.S. government dropped its protection of the domestic dyes industry and agreed to enforce the internationally negotiated General Agreement on Tariffs & Trade with the aim of ultimately eliminating protective duties. (Without protection, almost all U.S. dye makers—such as DuPont, Allied Chemical, and America Cyanamid—sold their dye businesses in the late 1970s and early '80s to more vertically integrated European competitors such as Hoechst, Ciba-Geigy, and BASF.)

Following World War I, in the U.S. the Chemical Foundation purchased German patents seized by the U.S. government as alien property during the war and worked to disseminate and sell those patents. Lawyer Francis Garvan headed the Chemical Foundation as president, and nearly all synthetic organic chemical makers held stock in the foundation. Garvan believed he had a patriotic duty to disseminate chemical know-how and support the development of the U.S. chemical industry. The patents the Chemical Foundation had purchased from the U.S. government for more than $270,000 covered dyes, nitrogen fixation, the Hoechst antisyphilitic drugs Salvarsan and Neosalvarsan, the Hoechst anesthetic Novocain, and various chemical processes.

In 1922, the Justice Department did attempt to recover patents sold to the Chemical Foundation in the court case *USA v. The Chemical Foundation,* citing the low purchase price paid and the great value of these patents. Scientists from U.S. universities and companies such as DuPont, Abbott Labs, and dyes maker Calco Chemical testified that the patents themselves were unworkable based on the descriptions they contained. To isolate the compound the patent secured required a great deal of additional research, and to make a commercially viable product required significant additional information that the patents did not contain.

In January 1924, Judge Hugh Morris of federal district court in Wilmington, Del., affirmed the Chemical Foundation's ownership of its patents. He ruled that even though the government sold the patents at less than market value, the patents were significant both to the U.S. industry and to national security. Their dissemination through the Chemical Foundation effectively prevented German manufacturers from securing the virtual monopoly over the supply of chemical products they had held before World War I. The court of appeals and the Supreme Court upheld the lower court ruling.

While the U.S. government helped protect the developing chemical industry with tariffs, the Justice Department appeared to hinder the development of the industry with its case against the Chemical Foundation. However, the Commerce Department was solidly behind the development of a U.S. chemical industry. In a speech before the newly formed Synthetic Organic Chemical Manufacturers Association (SOCMA) in 1921, then-Commerce Secretary Herbert Hoover promoted the industry because it used by-products that would otherwise pollute the environment.

Hoover encouraged synthetic organic chemical makers to advance their industry because "the very coke oven today that is not recovering its by-products, turning its by-products into the air, is

Eugene Houdry discovers crystalline aluminosilicate catalysts that boost the amount of high-octane fuel that can be derived from the cracking process.

A Monsanto laboratory in St. Louis.

turning a loss that can never be recovered. Your industries are the industries that take these derivatives and turn them to account. . . . If we are going to maintain our own in the world, we must turn all these waste factors into something productive, and an industry that is almost wholly founded on the recovery of those wastes naturally is worth cultivation and encouragement, not only by the country but by the government itself."

This close cooperation between the government and industry in the 1920s and '30s meant, for instance, that the newly formed SOCMA and its members worked closely with the government to set up a customs lab to test imported dyes for their similarity to dyes produced in the U.S. Counseling government lawyers on import tariff cases was one of the largest expense items in SOCMA's budget between 1923 and 1925.

During the 1920s, U.S. companies secured a measure of economic protection with tariffs, bolstered their patent positions with court victories, and found a staunch ally in the Commerce Department. DuPont built up a strong position in dyes on its own and through the purchase of Newport Co. in 1930. American Cyanamid, diversifying beyond calcium cyanamide fertilizers, also built up its dyes business with the purchase of Calco in 1929. Dow Chemical staked out a claim to the dyes business by developing a line of brominated indigo through a technical assistance agreement with Switzerland-based Ciba.

The 1920s also provided opportunities to develop synthetic resins—Leo Baekeland's phenol-formaldehyde-based resin Bakelite found use in the booming automotive market to make steering wheels, battery terminals, and spark plugs. Bakelite Corp. (bought by Union Carbide in 1939) also sold Bakelite to make the casing, knobs, and dials for a newly popular consumer item—radio sets.

Petrochemicals

The first commercial U.S. petrochemical unit was an isopropyl alcohol complex at the Standard Oil refinery in Bayway, N.J., which began operating in 1920. Later work on thermal cracking of light petroleum fractions led to the widespread development and use of petroleum-derived chemicals.

George Curme, a researcher at Mellon Institute, Pittsburgh, learned how to obtain ethylene and propylene from natural gas light petroleum fractions. In addition, his work at Mellon and later at Union Carbide led to a series of important ethylene derivatives. Among them were ethylene glycol, a product Carbide sold under the Prestone name for automobile and airplane engine antifreeze. Today, AlliedSignal owns the Prestone name and distributes the antifreeze (still made and, in part, supplied by Union Carbide). Other derivatives Carbide learned how to produce included ethylene oxide, ethylene glycol, dichloroethane, and ethyl alcohol. (Until Carbide developed its economical synthetic process, ethyl alcohol came from molasses fermentation.)

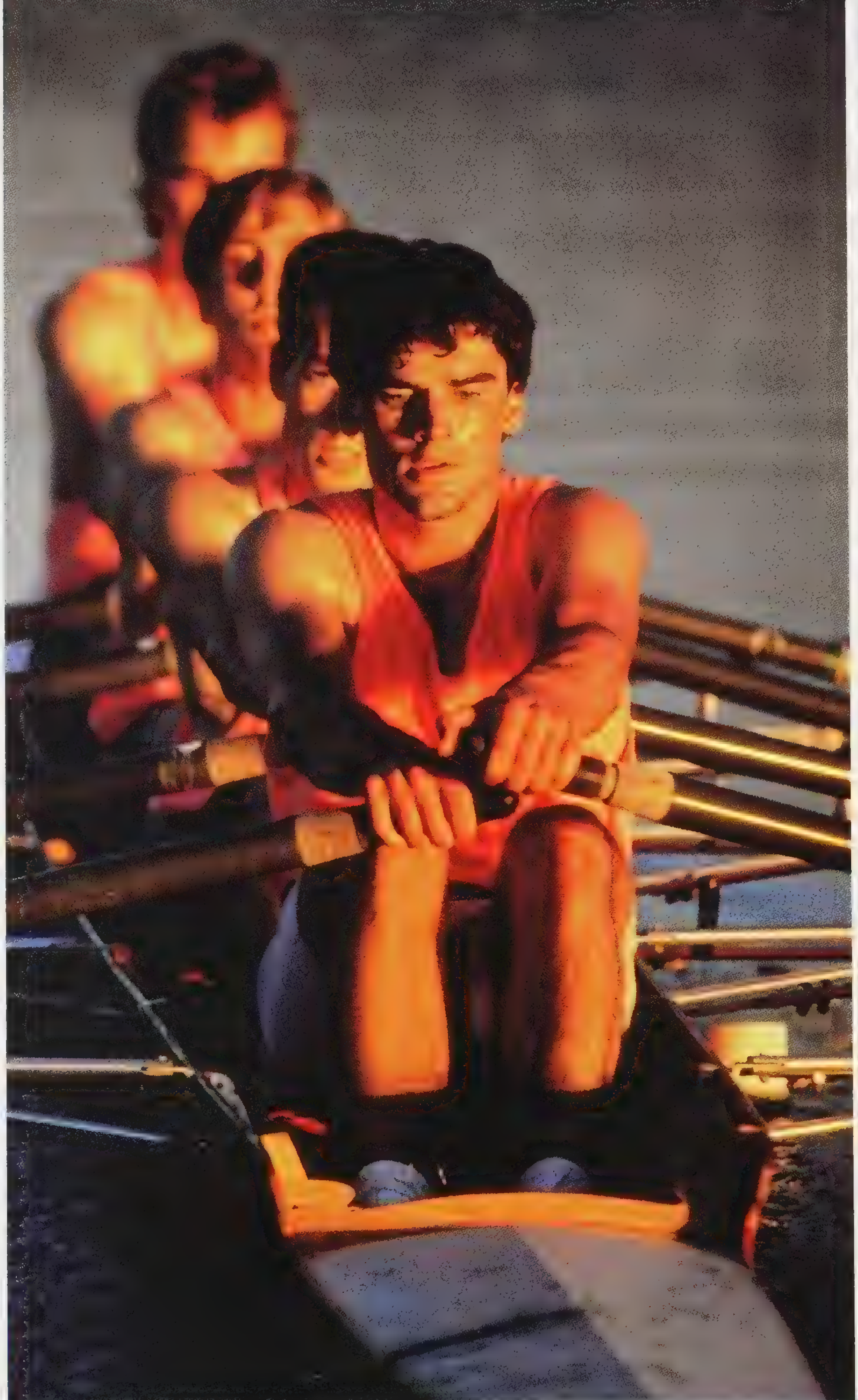
In 1920, Carbide converted a natural gas processing plant at Clendenin, near Charleston, W.Va., to develop manufacturing processes based on Curme's work. In 1925, Carbide set up a full-scale works in South Charleston, W.Va., to enlarge petrochemical production, drawing its raw materials from the surrounding West Virginia gas fields.

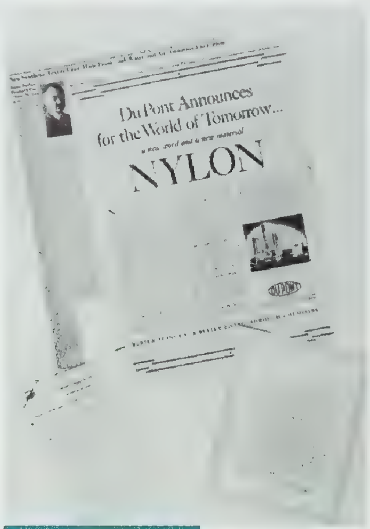
Another early pioneer in petrochemical development was Shell. Germany's I. G. Farben cartel had learned how to convert coal to gasoline and fuel oil, thus competing with Shell's fuel business. Shell decided it had to diversify. In the late 1920s, the Anglo/Dutch group set up a lab in Emeryville, Calif., near Berkeley. Headed by E. Clifford Williams, dean of the science faculty at London University, the lab learned how to produce secondary butyl alcohol—as well as methyl ethyl ketone—from thermal crude oil cracking operations. The ketone had only been available before as a by-product of wood distillation.

Work supervised by Williams at the Emeryville research site led to the production of synthetic gylcerin in 1937. The Shell process replaced glycerin available as a by-product of tallow for soaps, explosives, and alkyd resins.

I. G. Farben

In Europe, World War I had taken its toll on German society and the German chemical industry. Inflation following the war drove the value of the German reichsmark from 4.2 to the U.S. dollar in 1914 to 49,000 to the dollar by 1923. To some extent, inflation helped German chemical producers boost exports and begin to recover from the war's effects. But German chemical leaders also formed the Interessengemeinschaft Farbenindustrie Aktiengesellschaft (I. G. Farben) cartel in 1925 to allow members' companies to recover from the war and reduce bureaucracy,




Du Pont Announces for the World of Tomorrow...

NYLON

1938

DuPont announces nylon—the first commercial synthetic fiber.

Courtesy of the Othmer Library of the Chemical Heritage Foundation


1940

On May 15, crowds wait to purchase nylon stockings; 4 million pairs sold in a few hours.

prevent duplicative production efforts, and increase collective profits.

The I. G. Farben name literally translates as the "community of interests of the dye industry corporation"—a measure of the importance of the dyes business. But it actually included other manufacturing operations: nitrogen, methanol, pharmaceuticals, pesticides, photographic products, and artificial fibers. The primary members were BASF, Farben Fabriken Bayer, Farbwerke Hoechst, Agfa, Chemische Fabriken vorm. Weiler-ter Meer, and Chemische Fabrik Griesheim-Elektron. Although Cassella & Co. and Kalle & Co. remained autonomous, they transferred management responsibility to I. G. Farben.

The cartel was headquartered in Frankfurt. Carl Bosch of BASF became chairman of the board of management and Carl Duisberg of Bayer became the chairman of the supervisory board. I. G. Farben ultimately had a controlling interest in 379 German firms and 400 foreign firms. In the U.S., I. G. Farben controlled the American I. G. Chemical Corp. The basis for that company's dyes businesses was I. G. Farben's 1928 purchase of the Grasselli Dyestuffs Corp. I. G. Farben sold the heavy chemicals operations to DuPont and renamed the dyes business the General Aniline Works. In 1942, the U.S. government took over those operations, then part of the I. G. Farben-controlled General Aniline & Film Corp. (GAF). The U.S. government sold GAF to the public in 1962.

Cartel operations were an acceptable means of running businesses in Germany in the 1930s and were allowed by German law. The U.S.-based, Rockefeller-owned Standard Oil was, in fact, the model on which I. G. Farben and its German predecessor cartels were based. In the U.S., the Sherman Antitrust Act of 1890 contributed to the breakup of Standard Oil in 1911. The U.S. government also used the act to break up DuPont in 1912 and forced the spin-off of half of its explosives businesses to two newly formed competitors that became well-known chemical producers on their own—Hercules and Atlas. Atlas was purchased by the British chemical maker Imperial Chemical Industries (ICI) in 1971 and formed the basis of ICI's expansion into the U.S.

In other countries, formal cartels may not have existed, but in some cases very large companies exerted power and influence over the rest of the industry by their sheer size. In England, ICI dominated chemical production. It was formed in 1926 by the merger of Brunner, Mond & Co., Nobel Industries, United Alkali, and British Dyestuffs Corp. In France, four big companies led the industry: St. Gobain, Péchiney, Kuhlmann, and Rhône-Poulenc.

Polymers come of age

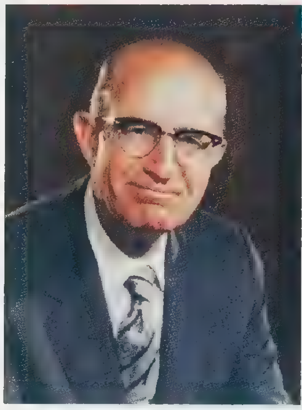
The Great Depression did not slow chemical industry development. U.S. and European chemical firms began research on polymers. Work on nylon, polyester, high-density polyethylene, and synthetic rubber took on an unexpected urgency in the late 1930s and early '40s when warring governments helped to speed the development of these thermoplastic and thermoset polymers to meet the pressing material requirements to fight World War II.

Harvard professor Wallace Carothers joined DuPont in 1927, and by 1935 he had successfully produced a nylon 66 polymer that DuPont would ultimately produce in fiber form. The discovery was not only important for the textile fiber industry, but it also proved that a U.S. scientist could take the lead in developing new technology "from coal, air, and water," as DuPont announced to the world in 1938 when it decided to build its first commercial nylon plant in Seaford, Del. However, widespread availability of nylon for stockings—as well as for upholstery, carpeting, and tire reinforcement—had to wait for the end of the war, during which nylon was used to manufacture parachutes.

German scientists were not far behind DuPont in developing nylon. Paul Schlack of Aceta, a member of the I. G. Farben cartel, had successfully produced nylon 6 in 1938. However, the war interfered with the development of nylon in Germany, and Bayer built the first commercial plant for nylon after the Allies broke up I. G. Farben.

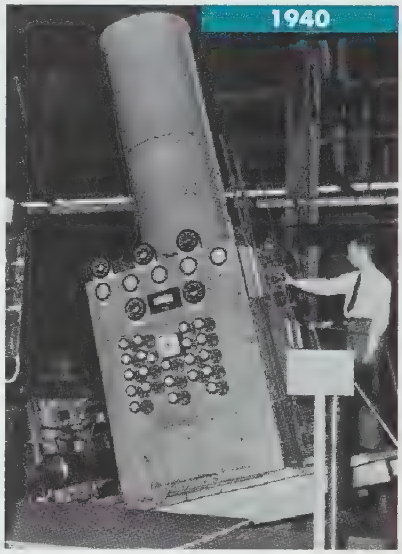
British scientists began work in 1939 to develop polyester. J. R. Whinfield and J. T. Dickson, working for an industrial lab operated by a group of printers, Calico Printers Association, filed the first patent for polyester fibers. ICI, which already produced the ethylene glycol monomer to make the new fiber, negotiated an agreement with Calico Printers to commercialize it.

The war effort drove development of polyester for fiber use, but the development efforts were not far enough along until the end of the war to be of any help to the war effort. DuPont scientists had also developed a polyester fiber in 1944



1940

Leonard Parker Pool founds Air Products on the strength of a simple, but revolutionary concept: on-site production and selling of industrial gases, such as this shipboard oxygen-nitrogen generator.



1940

at the company's research station in Wilmington, Del. When the war ended, DuPont purchased U.S. rights to develop polyester from ICI. DuPont began commercial production of Dacron polyester in Seaford, Del., in 1953, and ICI began Terylene polyester production in Wilton, England, in 1955. Ultimately, what goes around comes around. In 1997, DuPont bought ICI's polyester business, which included production capability for film and bottle polymer resin.

ICI work in the 1930s also led to the discovery and development of low-density polyethylene (LDPE). By 1939, the company had a plant capable of producing 100 tons of the material per year. During the war years, LDPE was used for electrical insulation for ship and airborne radar systems. Union Carbide had also produced LDPE at about the same time, but ICI was the first to patent the material. After the war—in the 1950s—LDPE found its way as an insulator into power cables, television, and radio sets.

Other important polymer developments in the 1930s led to the discovery and production of synthetic rubber. Bayer scientist Fritz Hofmann first made synthetic rubber from butadiene during World War I. After that war, low natural rubber prices restricted synthetic rubber to specialty applications. Among the specialty rubber developments of the day were the oil-resistant polychloroprene (trade name Neoprene) that DuPont and Thiokol produced in the 1920s and early '30s. I. G. Farben scientists worked on the production of synthetic rubber in the 1930s to gain rubber self-sufficiency for Germany in the event war cut the country off from sources of natural rubber for truck and tank treads.

Soon I. G. Farben companies BASF and Bayer had developed Buna-S, a styrene-butadiene rubber (SBR). Buna-N included the same ingredients as well as acrylonitrile. In the U.S., Standard Oil Co. (New Jersey) reached a technology exchange agreement with I. G. Farben on the production of vulcanizable elastomers. By 1937, Standard Oil (which became Exxon in 1972) researchers William J. Sparks and Robert M. Thomas mixed and developed a "large" batch of butyl rubber (formed from isobutylene and butadiene) at the company's Linden, N.J., laboratory in a washing machine purchased from retailer Sears Roebuck. Butyl rubber's air-holding capacity made it ideal for tire inner tubes.

Because of the technology agreement with I. G. Farben, a U.S. congressional committee investigated Standard Oil on charges it conspired with I. G. Farben to retard the development of synthetic rubber. Standard Oil, in fact, shared the technology it had on Buna-S with the government and other U.S. companies. As a result, Goodyear, BF Goodrich, Firestone, and U.S. Rubber (later Uniroyal) built SBR plants under contract with the U.S. government.

Petrochemical buildup

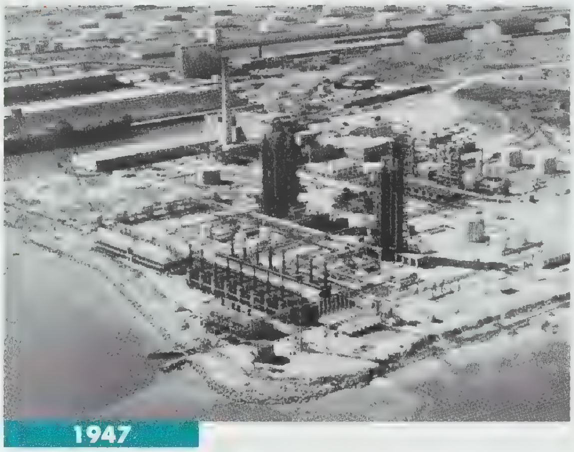
Providing the rubber production program with the raw materials butadiene and styrene also required the buildup of an enormous petrochemical base. Dow Chemical had worked on styrene technology in the early 1930s and had built a styrene plant in 1937. (Dow and Monsanto had first produced the thermoplastic polystyrene based on Dow's monomer in the late 1930s.) The war effort meant rapid scale-up of styrene production by Dow, Monsanto, Union Carbide, and Koppers.

Grain alcohol was one source of butadiene, but the most important and least expensive route depended on petroleum. Standard Oil Co. (New Jersey) built a number of plants to make butadiene from hydrocarbon fractions. It also built butylene dehydrogenation plants to supply butadiene using technology from Phillips Petroleum and Houdry Co.

Because of the war effort, improvements in petroleum refining also meant more petroleum by-products could be separated into feedstocks for the chemical industry. Technology to extract Pennsylvania and later Texas crude oil improved in the 1930s and '40s helped, in part, by Dow's brine oil well fracturing services. Automotive fuel demand and later military aviation fuel requirements during the war meant gasoline producers were under greater pressure to get more high-octane fuel out of a barrel of oil to power tanks, airplanes, and troop transport vehicles.

Reforms in steam and catalytic cracking of petroleum led not only to improvements in fuel manufacturing technology, but also to chemical derivative advances. Eugene Houdry's catalytic cracking process introduced in 1936 improved gasoline yield from oil and lowered reaction temperatures and pressures from then-current production methods. Sun Co.'s Marcus Hook, Pa., facility was the site of the first industrial Houdry fixed-bed catalyst unit. In addition to gasoline, new petroleum distillation processes produced quantities of ethylene, propylene, and butyl-


Witco



Monsanto's Texas City, Texas, styrene plant before and after it was destroyed as a result of an explosion on an offshore freighter loaded with ammonium nitrate fertilizer. This incident, which killed 512 people, made the public aware of the danger inherent in chemical manufacturing.

enes. Although largely used for heating purposes at first, these distillates were the basis for many commercial chemical products after the war.

Another pioneering petroleum distillation technology company at this time was Universal Oil Products (UOP), which started out as Standard Asphalt Co. However, the name changed when the company purchased patent rights developed by Jesse Dubbs that included early thermal cracking patents. Under the direction of Jesse's son, the happily named Carbon Petroleum Dubbs, and Gustav Egloff, UOP sold licenses for Dubbs crude and gas oil cracking units. Patent disputes led Shell Oil and Standard Oil Co. of California to join forces in 1931 with other oil companies to buy UOP and eliminate litigation as well as reduce their royalty costs.

But antitrust concerns dogged UOP, and, in the end, the oil companies that owned stock in UOP set up a trust to hold ownership with the earnings going to the Petroleum Research Fund (PRF), administered by the American Chemical Society. In 1947, UOP's Vladimir Haensel developed the noble metal platforming process that used platinum as a catalyst in refining naphtha to produce high-octane gasoline. The trust sold UOP to Allied Chemical (now AlliedSignal) in 1959, providing the Petroleum Research Fund with a $70 million endowment. UOP survives today as a joint venture of AlliedSignal and Union Carbide. And PRF continues to provide millions of dollars in research grants each year, administered by ACS.

Catalyst technology enticed a number of companies through the past decades to develop the technology for fuels and chemical production. They have included Engelhard, Degussa, and the Davison Chemical business that W.R. Grace bought in 1953 and still owns.

Antibiotics development

Not all chemical business efforts went to the development of fuels and industrial chemicals. Before, during, and after World War I, many firms concentrated their efforts on refining medical and related compounds. Some of these companies were Pfizer, E. R. Squibb & Sons (now Bristol-Myers Squibb), Merck, Monsanto, and Mallinckrodt. Companies such as Squibb were already producing the anesthetic ethyl ether. Monsanto's first product was not itself a pharmaceutical but the artificial sweetener saccharin, which was used to cover up the taste of bitter medicines. During World War I, Monsanto developed phenol for use as an antiseptic and acetylsalicylic acid, the raw material for aspirin.

But after the war, Germany's chemical companies reasserted their leadership in pharmaceuticals. Gerard Domagk at I. G. Farben's Bayer operations discovered the sulfonamides. Meanwhile, in 1928, Britain's Alexander Fleming discovered the first antibiotic, penicillin, in a common mold. But it was not until 1939 that Oxford University's Howard Florey and his colleague Ernest Chanin extracted enough penicillin to allow clinical trials.

Driven by the need for pharmaceuticals in World War II, Merck scientists focused on penicillin, and it was among the first to commercially produce penicillin from natural molds grown in huge tanks. Pfizer was also in that lead group. Pfizer scientist Peter Regna delivered the first U.S. paper on the isolation and purification of penicillin. Other firms that produced penicillin included Squibb, Lilly, and Abbott Laboratories.

The war effort spurred pharmaceutical companies to increase their search for new antibiotic drug therapies after the war. Parke, Davis came up with chloromycetin; Pfizer, with terramycin; and Lilly, with erythromycin—all before 1952. Such work led scientists and the companies employing them to a better understanding of natural molecules and then to develop methods to modify or mimic these molecules to fight illness.

Another important development started during the war years led Merck to develop a complicated 37-step synthesis of cortisone from cattle bile. The drug, still in use, alleviates symptoms of rheumatoid arthritis and other inflammatory ailments.

Consumer markets

The defeat of the Axis powers at the conclusion of World War II meant that German chemical patents and processes were again available to enterprising U.S. and other chemical makers. Chemical engineers on loan from U.S. chemical enterprises to the Department of Commerce explored Germany's chemical works. Many of the plants they reviewed, along with French and British chemical engineers, allowed companies from Allied countries to exploit German process technology such as the Claus process to convert hydrogen sulfide to sulfur or the conversion of methane to acetylene.

U.S. industry, with its commercial plants unaffected by the destruction of

Rohm and Haas produced Plexiglas for World War II airplanes; after the war, the product found lighter hearted uses, like jukeboxes.

war, was confident of the future and prepared for growth. That optimism, though, had to be tempered with reality. The industry's first huge disaster struck on April 16, 1947, when a French freighter, the *S.S. Grandcamp,* blew up at a dock 270 feet from Monsanto's Texas City, Texas, plant on the Gulf Coast. The freighter had 2,500 tons of ammonium nitrate on board. The blast destroyed Monsanto's styrene and new polystyrene facility. More than 200 people died at the plant—and including contractors and people living in nearby Texas City, a total of 512 perished.

Monsanto Chairman Edgar Queeny explained to Monsanto shareholders and employees that, "No manufacturing plant is designed as a fortress, nor could many fortresses withstand a blast such as came from the *Grandcamp*." Monsanto rebuilt its plant within two years after the accident. Although Monsanto did not cause the accident, and in fact took great pains to care for those injured in the blast and the families of workers killed and injured, the incident put people on notice that handling chemical products carried risks. Many in the industry would remember the Texas City incident in the next few decades as chemical products came under scrutiny, beginning in the 1960s, for the environmental health and safety hazards they posed.

The Korean War again diverted U.S. industry to supply materials to the war effort in the early 1950s, but the resumption of peacetime conditions after 1953 allowed many chemical companies to exploit the advances in technology brought about during the war. Plastics and fiber producers began to manufacture products for consumer articles and textiles. Plants developed in cooperation with the U.S. government to provide synthetic rubber for military uses were converted to supplying synthetic rubber for tires, belts, gaskets, and other items used in automobiles, trucks, and farm equipment needed to drive a civilian economy.

In the 1950s, Rohm and Haas, for instance, took the acrylic sheet technology developed in collaboration with Röhm of Germany during the 1930s and developed the sheets for illuminated signs and car lights. During the war, Rohm and Haas had developed the acrylic Plexiglas sheets as lightweight fighter plane cockpit enclosures.

One company, Air Products, took technology to manufacture mobile oxygen generators during the war and turned it into an opportunity to supply customers with on-site oxygen. Air Products' founder Leonard Pool, in the 1950s, enlarged a business of leasing oxygen generators to steel manufacturing customers into a major gas supplier. In 1961, he changed the name of the firm to Air Products & Chemicals as he built it into a major chemical maker, largely through acquisitions. In those early years, Air Products bought catalyst maker Houdry Process Corp., and Escambia Chemical, a producer of polyurethane resin precursors and other industrial and agricultural chemicals based on natural gas.

In the 1950s, European chemical producers rebuilt their industry largely along the lines of the U.S. chemical industry. Just about all chemical manufacturers saw petroleum and gas as the most versatile and economic raw materials, even though European companies had to import oil from Saudi Arabia and other oil-producing states in the Persian Gulf. The discovery of natural gas fields off the Dutch coast at Groningen in the '50s and the subsequent discovery of large natural gas deposits in the North Sea, led to the further development of petrochemical stocks for both fuel and petrochemicals in Europe. Aiding chemical trade within Europe was the Treaty of Rome in 1957 and subsequent amendments that formed the European Economic Community as a trading bloc.

By 1951, the Allied countries controlling West Germany finally broke up the old I. G. Farben. Three major companies—Bayer, BASF, and Hoechst—emerged along with a few smaller companies such as Chemische Werke Hüls, Cassella, and Anorgana. They all began to rebuild their organizations and foreign associations just as their predecessors had done after World War I.

In 1954, Bayer, for instance, began to expand into the U.S. with a new class of materials: polyurethanes. Together with Monsanto, Bayer created Mobay to manufacture the isocyanates and polyols used to form polyurethane foams for auto seats. The chemistry, a product of Otto Bayer's polyurethane research in Germany beginning in 1937, allowed Bayer to get a foothold in the U.S. with the formation of Mobay. Monsanto provided much of the financing while Bayer provided much of the technology and know-how. In 1977, Bayer bought out its partner because of U.S. antitrust actions.

Mobay formed the basis for Bayer's present \$9 billion-per-year North American operation, which now not only in-

Historic chemical icons become landmarks

To establish reminders of "where we have been and where we are going," the American Chemical Society launched a National Historic Chemical Landmarks Program in 1992. The society has recognized 16 landmarks to date.

A project of the society's Division of the History of Chemistry, the program's aim is to compile "an annotated roster for chemists and chemical engineers, students, educators, historians, and travelers."

The first icon to enter the annotated roster in 1993 was Leo Baekeland's original Bakelizer. The unit sits in the Smithsonian Institution's National Museum of American History in Washington, D.C. The vessel, known to its early operators as "Old Faithful," is the original steam-pressure vessel Baekeland used to commercialize the world's first synthetic plastic—the phenol formaldehyde resin called Bakelite. The material opened the door to an era of synthetic materials, and it found its way into nonconducting radio parts, light bulb sockets, and automobile distributor caps.

Other icons have entered the list since. In 1994, the society entered two new landmarks on its register. The first, the William H. Chandler Chemistry Laboratory, is on the campus of Lehigh University in Bethlehem, Pa. The lab, built in 1884–85, set the standard for laboratory construction and design for a half-century after, and it served as the setting for advances in chemical education. Novel features in the lab included steam-heated reaction baths, modular benches, transom-regulated ventilation, vertical service chases, and below-ground storage for fuel, ashes, and chemicals.

The second landmark recognized in 1994 was the Joseph Priestley House in Northumberland, Pa. The English chemist, who built the house in 1795, did important work on oxygen and other gases. He had emigrated to the U.S. because of his religious views and sympathy for the French and American Revolutions. Considered the cradle of American chemical research, the home housed 1,600 volumes and a chemical laboratory where Priestley first isolated carbon monoxide. A centennial celebration in 1874 at Priestley's home of the discovery of oxygen ultimately led many of its organizers to found ACS two years later.

The fourth chemical landmark, and the first of four designations in 1995, was the designation of Edward W. Morley's research on the atomic weight of oxygen. ACS placed a plaque at the 19th-century site of Morley's laboratory in Adelbert Hall on the campus of Case Western Reserve University in Cleveland. Next to receive a plaque marking its historical significance was the Seaford, Del., site of DuPont's first commercial nylon plant in 1939.

The society then conferred the landmark designation on Eastman Chemical's coal-to-chemicals facility—the first to produce acetyl chemicals from coal rather than petroleum. The plant started production in 1983 after eight years of research and coal gasification process development prompted by the Arab oil embargo of 1973. The use of locally mined high-sulfur coal displaces 1.5 million barrels of oil previously required per year to produce acetyl chemicals.

And also in 1995, the UOP Riverside Laboratory in McCook, Ill., gained recognition. Conceived as a quiet academic retreat, the lab attracted leading petroleum scientists who secured 8,790 patents between 1921 and 1955, many relating to the understanding of hydrocarbon rearrangement, isomerization, and polymerization.

In 1996, ACS entered the Williams-Miles History of Chemistry Collection at Harding University, Searcy, Ark., into the landmarks program. The library contains more than 2,000 volumes on chemistry published between 1600 and 1900.

Three other landmarks entered the program in 1996. One commemorated the Houdry process for the catalytic conversion of crude petroleum to high-octane gasoline, with a plaque placed at the Marcus Hook, Pa., refinery of Sun Co. In 1937, the refinery installed the first large-scale catalytic unit to transform crude oil into gasoline. Eugene Houdry's process, the basic principles of which are still applied to the manufacture of gasoline, produced a higher octane fuel than the thermal cracking methods widely practiced in the 1920s and '30s.

Also in 1996, ACS presented a plaque to Sherwin-Williams, in Cleveland, commemorating the 1941 introduction of Kem-Tone wall finish, the first commercially successful, multi-million-gallon, waterborne interior wall paint with colors that could withstand rubbing and washing. And in the same year, it commemorated the Sohio acrylonitrile process. In 1957, researchers at Sohio (now BP America) developed a single-step method to produce acrylonitrile at the company's Warrensville Lab in Warrensville Heights, Ohio. The availability of plentiful and inexpensive acrylonitrile led to dramatic growth in derivative acrylic thermoplastics and synthetic fibers.

In 1997, ACS placed five landmarks on its roster. The first marked the commercialization of radiation chemistry by founders of Raychem Corp., Redwood City, Calif. The plaque placed with Raychem recognizes the successful use of ionizing radiation in 1957 to cross-link polymeric materials to give them special properties, such as strength, toughness, and improved high-temperature performance.

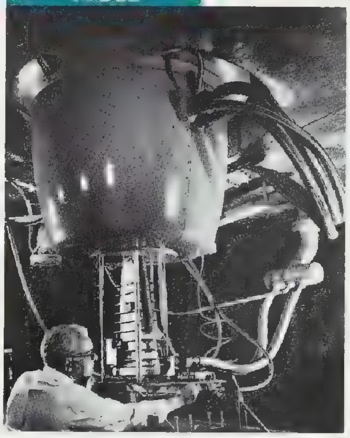
The second plaque ACS placed in 1997 is at the replica of Evens Mill in Midland, Mich., to commemorate Herbert H. Dow's electrolytic production of bromine. Dow perfected a commercial electrolytic process using brines from a well at the site, now the home of the Herbert H. Dow Museum. The Dow Chemical Co., founded to commercialize another product of Herbert Dow's electrolytic experiments with brine—chlorine—celebrated its 100th anniversary in 1997 as well.

The third plaque commemorates the 1886 production of aluminum metal by electrochemistry. Presented to Oberlin College in Oberlin, Ohio, the plaque celebrates Charles Martin Hall's success in producing aluminum metal by passing an electric current through a solution of aluminum oxide in molten cryolite. Hall conducted his experiments in a woodshed behind his family's home in Oberlin. His work was the basis for an aluminum industry in North America.

The landmark program added Gilman Hall at the University of California, Berkeley, to the roster. This research and teaching facility, dedicated in 1918, provided a setting for advances in physical, inorganic, and nuclear chemistry. Gilbert N. Lewis, who came to Berkeley to head the college of chemistry and chemical engineering, helped advance the university's strength in chemical thermodynamics and molecular structure. Willard F. Libby, trained as a nuclear chemist at Gilman Hall in the 1930s, received the 1960 Nobel Prize in Chemistry for carbon-14 dating. Glenn T. Seaborg also trained at Gilman Hall, and, as a faculty member in 1941, he identified the first known isotope of plutonium with colleagues Joseph W. Kennedy, Edwin M. McMillan, and Arthur C. Wahl.

The most recently placed plaque commemorates the discovery of the antiulcer compound cimetidine. A joint designation of ACS and the U.K.'s Royal Society of Chemistry, it is the first international landmark. Smith Kline & French (now SmithKline Beecham) research scientists carried out the initial work at company labs at Welwyn Garden City in the U.K. in the 1970s. In 1998, a plaque will also be placed in Philadelphia, where company scientists carried out the subsequent development of a commercially viable synthesis route. From this work came Tagamet, a histamine receptor agonist now available over the counter, one of the first drugs to be designed logically from first principles rather than based on a plant or microbial extract.

1950s



Raychem Corp. uses radiation to create cross-linked polymers that are strong, tough, and resistant to abrasion and high temperatures.

1962

Floyd (left) and Bruce Gottwald, shown here in 1994, owners of Albemarle Paper, buy Ethyl Corp. in what was then the largest leveraged buyout on record.

Photo by Marc Reisch

cludes polyurethanes, but also pharmaceuticals, analgesics, crop protection chemicals, inorganic pigments, and spandex fibers. In a recent deal with its old partner Monsanto, Bayer acquired Monsanto's styrenics business.

Polymers accelerate

The 1950s and '60s were a period of general optimism for the chemical industry in the U.S. and Europe as technical advances formed the basis for new chemical product lines. Bayer and General Electric developed polycarbonates simultaneously in the mid-1950s, although large-scale commercialization did not begin until 1960. Dow Corning, set up as a joint venture between Dow Chemical and Corning Glass Works in the early 1940s, grew in the '50s as a major supplier of silicone elastomers and lubricants. General Electric was also an early producer and competitor in the silicones market.

Advances in polyethylene and polypropylene in the 1950s also helped establish these useful plastics as universal materials. Although ICI and DuPont were already producing high-pressure polyethylene for applications such as electric wire insulation, Germany's Karl Ziegler isolated a low-pressure crystalline polyethylene that seemed promising. Ziegler had begun work on ethylene polymerization in the 1930s at the Kaiser Wilhelm Institute for Coal Research in what was to become East Germany after the war, and he carried the work to completion on organometallic catalysis of polyethylene at the Max Planck Institute formed in Mülheim in West Germany after the war. Hercules started up the first low-pressure crystalline polyethylene unit in the U.S. in 1957 based on a license from Ziegler's patents; Koppers and Union Carbide soon followed.

Ziegler's was not the only new process for producing polyethylene. Phillips Petroleum had perfected its own process to make crystalline polyethylene. By the time the Hercules plant was operating, Grace, Celanese, and Allied Chemical were also producing polyethylene using Phillips' process. Ultimately, 15 U.S. companies became polyethylene producers.

Giulio Natta, a chemical engineer working at the Milan Polytechnic Institute, in 1954 discovered another polyolefin—polypropylene—which had a melting point of 170 °C. The melting point of Ziegler's polyethylene was 145 °C. Financed largely by Italian chemical maker Montecatini, Natta had pursued an extension of Ziegler's catalysis technology allowing the use of propylene instead of ethylene. For their work, Natta and Ziegler shared the 1963 Nobel Prize in Chemistry.

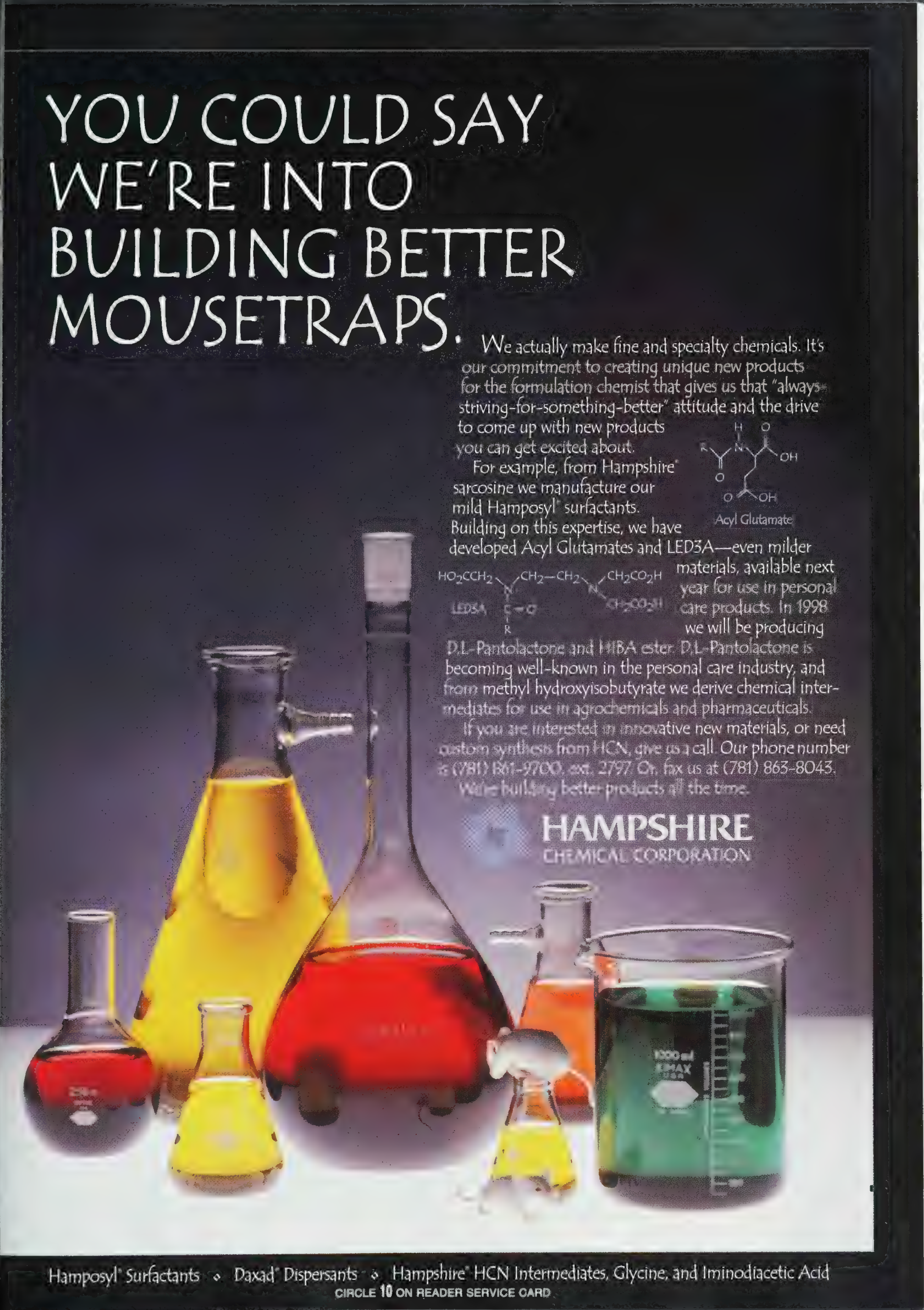
Natta's polypropylene was particularly suited for molded objects such as housewares, textile fibers, and film. Whereas 17 U.S. producers eventually made polypropylene, Hercules became the world's first commercial crystalline polypropylene producer in 1957 and for many years was the leading producer.

Rapid growth and the resulting corporate restructuring has affected many of the chemical industry's products and their manufacturers. The disposition of Hercules' original polypropylene unit over the past 40 years is a paradigm for many other chemical businesses and is proof of corporate ingenuity if nothing else.

Hercules started with about 10 million lb of annual polypropylene capacity in 1957. In 1983, Hercules formed a joint venture called Himont with Italy's Montedison. The venture then had 2.5 billion lb of annual capacity and $750 million in sales. The partners sold a 22% interest in Himont to the public in 1987, and later that year Hercules sold its remaining interest to Montedison. Himont's 1987 sales exceeded $981 million and its annual capacity approached 3 billion lb.

By 1990, Montedison had bought the outstanding public shares of Himont—a company that then had annual sales nearing $2 billion and polypropylene capacity of almost 4 billion lb. Montedison made Himont into another of the many subsidiaries that the byzantine company controlled. In 1995, Montedison merged Himont into a joint venture with Shell Chemical's polypropylene business to form Montell, creating a producer with more than $3 billion in annual sales and more than 7 billion lb of polypropylene capacity. And just last year, Shell worked out an agreement to buy out Montedison for $2 billion. Montell now has nearly 8 billion lb of annual polypropylene capacity and sales approaching $4 billion per year.

Advances in other fields also helped enlarge chemical companies' involvement in useful products. Not only were some firms involved in the production of fertilizers, but many others isolated new compounds to protect crops from insects and fungal attack. Early I. G. Farben work on organophosphorus compounds disclosed after World War II led American Cyanamid to develop the insecticides parathion and malathion. Union Carbide successfully developed carbamate insecticides in the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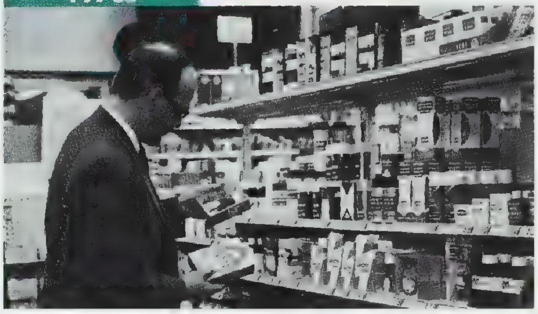
CIRCLE 10 ON READER SERVICE CARD

1970s



Consumers have come to expect having a variety of personal care and over-the-counter pharmaceutical products to choose from.

1970s

1950s, and sold them under the trade name Sevin. American Chemical Paint put the herbicide 2-4-D on the market in the late 1940s, and DuPont developed substituted ureas as herbicides in the early '50s.

Chemical engineering

Aiding much of the capacity buildup in the chemical industry during the 1950s and subsequent years were the many chemical engineering companies. M. W. Kellogg, Stone & Webster, Bechtel, Lummus, and Foster Wheeler played an important part in both building and spreading technology, not only in the U.S., but also in Europe and in more recent years to Eastern Europe, Latin America, and Southeast Asia.

Among the most enterprising chemical engineering firms was Scientific Design Co., founded in 1946 by Ralph Landau, Harry Rehnberg, and Robert Egbert. Working in a New York City office building, Landau and his team developed a novel fixed-bed oxidation process to make ethylene glycol. The process was thought to be more economical than Carbide's in the early '50s. Landau and his colleagues licensed the process first to a British firm, Petrochemicals Ltd. (Shell bought the company in the mid-1950s.) Scientific Design also sold a license to Naphtha-chimie, a joint venture of French firms Pechiney and Kuhlmann, allowing the partners to build an ethylene oxide and ethylene glycol plant in Lavera, France. Others followed.

Scientific Design also developed processes and sold licenses to make chlorinated solvents and maleic anhydride. One of the biggest breakthroughs was the firm's development of a catalyst to oxidize *p*-xylene into purified terephthalic acid, an essential ingredient in the manufacture of polyester fibers as well as, in more recent years, bottle polymers. Scientific Design licensed the technology to ICI, which had been working on a similar process for its Terylene polyester production. In 1956, Scientific Design sold worldwide rights to the process to Amoco Chemicals. The Chicago-based subsidiary of the big oil refiner and gasoline marketer is now one of the largest producers of purified terephthalic acid.

Scientific Design later became Halcon International SD. Landau and his associates developed a process for the production of propylene oxide and styrene through oxidation of propylene. In 1967, Atlantic Richfield Co. (Arco) and Halcon formed a joint venture, Oxirane, to produce styrene, propylene oxide, and *tert*-butyl alcohol. In 1980, Arco bought out Halcon's interests and consolidated the venture within its Arco Chemical Co., now based in Newtown Square, Pa. Halcon had fallen upon hard times because of losses from an experimental ethylene glycol unit the company built and operated.

During the 1950s and into the 1960s, as the industry advanced technologically, the demand for chemical products increased at double-digit rates, and the size and complexity of its plants grew. Tire companies had been involved in the synthetic rubber plants built during World War II, and Goodyear, Goodrich, Firestone, and U.S. Rubber maintained their involvement after the war, adding other chemicals to their portfolios as well. Some oil companies had been involved in petrochemical production in the 1930s and '40s, including Shell and Standard Oil Co. (New Jersey). But many expanded into petrochemicals in a big way in the heady 1950s—Arco, for example, and Continental Oil Co. (Conoco, now a subsidiary of DuPont), Standard Oil of Ohio (now owned by British Petroleum), and Amoco.

Other entrants into the chemical business at this time included natural gas transmission companies Tenneco and El Paso Natural Gas. Textile companies such as Beaunit and J. P. Stevens also set up chemical units, as did the big shipping outfit W.R. Grace. Albemarle Paper Manufacturing Co., controlled by the Gottwald family of Richmond, Va., acquired Ethyl Corp., a producer of tetraethyl lead gasoline octane improver, from owners General Motors and Standard Oil Co. (New Jersey). By borrowing $200 million in 1962, Albemarle successfully acquired a company 18 times its size in what was at that time the largest leveraged buyout on record. (A leveraged buyout provides for a loan guarantee against the value of the assets acquired.)

Pittsburgh Plate Glass (PPG), a major glass producer, had actually been involved in chemicals through the manufacture of sodium carbonate for glass and in the manufacture of paint. But PPG enlarged its chemical involvement after World War II, setting up a separate chemicals division in 1961 through which it manufactured chemical products such as chlorine, caustic soda, chlorinated solvents, and vinyl chloride.

A number of chemical companies diversified in downstream consumer products. Dow introduced its Saran plastic film wrap in 1954 and enlarged a consumer

1976

A bronze statute commemorates the creation of Genentech, one of the first major U.S. biotechnology-based pharmaceutical companies. The decision to form the company was made during a discussion over a beer between University of California, San Francisco, biochemist Herbert Boyer (right) and financier Robert Swanson.

1970s

Bethlehem Steel's plant produces coke from coal, with by-products that include tar, naphthalene, and light oil.

product franchise that included Ziploc bags and cleaners in the 1960s, '70s, and '80s. (Dow recently announced the sale of its DowBrands consumer products business to S. C. Johnson & Son in order to focus on its upstream chemical businesses.)

Successful growth meant that a number of companies expanded into new chemical markets. It also meant that chemical makers would become more acquisitive. Sometimes, the acquisition attempts were roundly rebuffed. In 1962, for instance, ICI tried to take over English textile maker and synthetic fiber producer Courtaulds without success.

Sometimes expansion into new chemical markets meant expansion into foreign countries. Indeed, the chemical industry has long been a global affair. Beginning in the 1950s, U.S. companies such as Dow built a complex in Terneuzen, the Netherlands, near Rotterdam, to produce styrene, polystyrene, ethylene oxide, and glycols. It also set up electrolysis units in Stade in Germany. Monsanto set up a headquarters in Brussels and produced fibers in Northern Ireland and Luxembourg. It also produced polystyrene, polyvinyl butyral, and rubber chemicals in Britain, Belgium, France, and Germany. Union Carbide set up chemical production units in Sweden, Belgium, India, and Australia.

Environmental issues

But even as expansions and rearrangements of assets took place in the 1960s, the industry came under attack because of the health effects of some of its products and also for its housekeeping practices. Rachel Carson's 1962 book, "Silent Spring," indicted the industry for the reckless misuse of chemical pesticides. She charged that pesticides spilling off cropland killed fish, birds, and other wildlife. And she wrote that these same pesticides also posed dangers to domestic animals as well as to human beings.

Many of these charges continue to haunt the chemical industry. Napalm—a chemical firebomb consisting of polystyrene, benzene, and gasoline—seemed to embody the very essence of a chemical threat. Although first used in World War II, napalm was widely used against Viet Cong soldiers, and in some cases against civilians, in the unpopular war the U.S. fought against the establishment of a communist government in Vietnam. Dow was the major producer of this "jellied gasoline," but other producers included United Technology, a subsidiary of United Aircraft, and Witco.

Another chemical threat that still looms large in retrospect is agent orange. Hercules, Dow, Diamond Shamrock, Monsanto, Uniroyal, and others manufactured the defoliant to clear the thick jungle growth as the U.S. fought in Vietnam. Many veterans claim exposure to the chemicals made them ill.

Public concern about the nature of chemical plant operations and their products forced a number of government actions. In the U.S., the federal government enacted a number of environmental restrictions that forced many chemical companies to change not only their product lines, but also their production and waste treatment methods. Beginning in 1965, the U.S. government enacted the Water Quality Act, and then followed with other major pieces of legislation including the Clean Air Act of 1970; the Occupational Safety & Health Act of 1970; the Federal Insecticide, Fungicide & Rodenticide Act of 1972; the Safe Drinking Water Act of 1974; the Resource Conservation & Recovery Act of 1976; and the Toxic Substances Control Act of 1976. European governments also passed environmental legislation.

Energy crises

The chemical industry continued to grow and prosper in the 1960s and into the early '70s despite the environmental imperatives confronting chemical producers. But as chemical companies continued to build new plants to satisfy growth expectations, overcapacity began to compromise some chemical producers. An oil crisis in 1973, and then again in 1979, put a real kink into the flow of industry profits, and the subsequent inflation and currency exchange rate problems also hurt profits.

The Organization of Petroleum Exporting Countries (OPEC), a cartel of major petroleum-producing countries, first forced world oil prices from $3.00 to $12 per barrel in 1973. The group, led by Arab oil-producing countries, attempted to embargo shipments of oil to countries that supported Israel in the Arab Israeli war of 1973. Later in the decade, the Iranian Revolution also put a crimp into world oil supplies, and prices per barrel of oil rose as high as $40.

The resulting high prices for energy and feedstock forced a number of chemical companies to consolidate. Some firms were isolated from the oil shock somewhat, such as Dow because of its Brazos Oil & Gas Division. DuPont simply went out and bought an oil compa-

CIRCLE 45 ON READER SERVICE CARD

CIRCLE 29 ON READER SERVICE CARD

1970s

Photo by Lois Ember

The hazards of chemical waste dumping—Love Canal, N.Y., and the so-called Valley of the Drums, near West Point, Ky., are two examples—lead to many new federal regulations.

1984

Photo by Marc Reisch

Gordon Cain spends $506 million to create Vista Chemical from the surfactants and polyvinyl chloride operations of DuPont's Conoco subsidiary.

ny, Conoco, in 1980 to insulate itself from the effects of fluctuating oil and gas availability and gyrating prices.

Because of these rough times, many producers realized they had too many operations, particularly in petrochemicals, and began to shed them. Among the willing buyers in the mid-1980s was Jon Huntsman, who began to build a large commodity chemical business with the purchase of styrene and polystyrene operations from Hoechst.

Gordon A. Cain also took advantage of the business climate at that time. In 1984, he and his investment banking operation, Sterling Group, created Vista Chemical out of the former DuPont Conoco surfactant and polyvinyl chloride chemical operations. In 1986, his group created Sterling Chemicals with the purchase of Monsanto's Texas City plant, which produced styrene, acrylonitrile, acetic acid, and other commodity chemicals. Cain Chemical, created in 1987, assembled an ethylene and ethylene derivatives giant with assets purchased from DuPont, ICI, Solvay, Union Pacific, and PPG.

Cain and his group anticipated a resurgence in demand for petrochemicals. Cain and those who invested with him, including plant managers and line operators, sold Cain Chemical to Occidental Chemical in 1988, netting a 44 to 1 payout. Cain himself had invested $2 million and walked away with about $100 million. Vista went public in 1986 and then was bought by Germany's RWE and merged with its Condea operations. Sterling went public in 1988 and was repurchased by the Sterling Group in 1996 after the firm rebuffed an offer from Huntsman Corp.

While Cain and Huntsman took advantage of industry asset disposals, others reshuffled operations to build positions where they believed they had or ought to have market strength. Many companies profited from the dismemberment of Stauffer Chemical, especially European-based chemical producers that saw the U.S. as an attractive, low-cost environment in which to conduct business.

The dismemberment of Stauffer had its beginning in 1985 when Chesebrough-Pond's, a diversified manufacturer of consumer goods—including cosmetics, clothing, and sporting equipment—acquired Stauffer. The chemical maker had suffered from declining profits because of weakness in its fabricated plastic products business and in agricultural chemicals.

While Chesebrough-Pond's hoped to eliminate itself as a takeover target with the purchase of Stauffer, it did not scare off Unilever, an Anglo/Dutch conglomerate. Unilever bought Chesebrough-Pond's in a $3.1 billion deal completed early in 1987. However, Unilever was not interested in the Stauffer Chemical businesses and sold those to ICI for $1.7 billion by mid-1987. Since its purchase of Atlas Powder in 1971, ICI had built a large base of chemical operations in the U.S.

But ICI was only interested in retaining Stauffer's agricultural chemicals businesses, which boosted ICI to the fifth largest U.S. agricultural chemical producer from 20th place. ICI had sold much of its bulk chemical interest to Cain's group a few years earlier and did not want Stauffer's. By September 1987, ICI had a deal to sell Stauffer's basic chemicals segment to France's Rhône-Poulenc for $522 million. ICI was not interested in the specialty chemical operations either. It sold them a few months earlier to the Dutch chemical maker Akzo (now Akzo-Nobel, following its 1994 merger with Sweden's Nobel industries) for $625 million.

Takeovers, litigation

In the competitive environment of the 1980s, any liability could provide an opportunity for one chemical enterprise to enlarge its franchise with the purchase of a weaker competitor. In 1984, Union Carbide's 51%-owned Bhopal, India, plant leaked a fatal cloud of methyl isocyanate, the base ingredient for the insecticide Sevin. The company came under attack by the Indian government seeking compensation for thousands of victims, environmental activists who questioned the company's operating methods, and opportunists who saw an excuse to acquire a major petrochemical company—cheap. Carbide had to fight for its life.

GAF Chairman Samuel J. Heyman, a lawyer and real estate developer who had taken over GAF after a proxy fight in 1983, made a bid for Carbide stock in 1985. Carbide first fought back through the legal system and through an offer to shareholders to repurchase their shares with cash and securities valued at more than Heyman's offer. Although Heyman did not succeed, the fight bruised Carbide. Under duress from the continuing aftermath of the Bhopal disaster, the company shed a number of businesses including its consumer battery and antifreeze operations and its carbon business.

Heyman made a nice profit on the Carbide shares he had bought. The acquisitive

1980s

Photo by Ann Thayer

Recycling of plastics—such as polyethylene terephthalate bottles—gains popularity among consumers; the technology and economics follow.

1984

Photo by Wil Lepkowski

Accidental, massive release of methyl isocyanate gas from Union Carbide's majority-owned pesticides plant in Bhopal, India, results in thousands of deaths.

Heyman also made a bid in 1987 for plastics maker Borg-Warner. But the investment banking company Merill Lynch succeeded in buying that firm. Here, too, Heyman made good money on the shares he sold to the buyer. General Electric ultimately bought Borg-Warner in 1988.

The Bhopal accident and the accumulation of environmental charges leveled against the chemical industry following "Silent Spring" finally resulted in unified action by the chemical industry. Led in part by Carbide itself, the industry began in 1985 to put together the now well-known Responsible Care program.

Under the auspices of the Chemical Manufacturers Association, nearly all major U.S. manufacturers have adopted programs to ensure safeguards for employees, users, and transporters of chemicals. The program includes initiatives to inform local communities about plant operations. Modeled after a program started by the Canadian Chemical Producers Association, the goal of the Responsible Care program is to ensure a climate ultimately allowing for the continued and safe production of chemical products.

The complex business environment has also forced major chemical companies to consider carefully the impact their products may have on litigious users. Legal suits in the 1970s and '80s against U.S. companies that produced agent orange under government contract were only an early warning. Dow Chemical had to defend its Merrell Dow Pharmaceutical subsidiary against charges that its drug to treat pregnant women for morning sickness caused birth defects. And although Dow never paid a claim and won a landmark U.S. Supreme Court decision in 1993 that requires the use of peer-reviewed science in federal courts, the product liability suits have kept coming.

Among the most notable are court fights over alleged damages DuPont's fungicide Benlate caused on crops in the early 1990s. Another court fight involved allegedly defective materials—acetal resins supplied by DuPont and Hoechst and polybutylene resins supplied by Shell—to manufacturers of pipes and connectors for plumbing.

And, of course, there is the quintessence of all chemical industry litigation, that alleging illnesses caused by silicone gel breast implants in women, which began in 1994. The avalanche of lawsuits has resulted in the bankruptcy of one implant maker, Dow Corning, a joint venture of Dow Chemical and glass maker Corning. And it has tied up other implant makers—including Bristol-Myers Squibb, 3M, and Baxter Health Care—in court for years.

The litigious climate has forced chemical producers to carefully consider to whom they sell their materials. Because of concerns over product liability, Hoechst, Dow, and DuPont, among others, have said they will not sell their polymers for use in any medical devices implanted into the human body.

Focus on core competencies

Although a number of large chemical companies have continued to focus on bulk commodity chemicals, many have developed specialty chemicals from their commodity base to boost their profits and product offerings. ICI, for instance, has made efforts in recent years to enlarge its paints franchise. In the U.S., ICI bought Glidden in 1986, and it continues to acquire large and small paint operations around the globe. A complex, and in recent years not very profitable, company, ICI has taken the gospel of specialty chemicals more to heart than most of its competitors.

When it split off its Zeneca pharmaceuticals and fine chemicals business to shareholders in 1993, the remaining ICI businesses were largely committed to bulk chemicals. Last year, ICI cut ties to most of its huge titanium dioxide and polyester businesses, selling them to DuPont. It also sold off its ICI Australia commodity businesses. In their place, ICI spent some $8 billion to purchase Unilever's specialty chemicals operations, which include U.S.-based adhesives producer National Starch & Chemical; fragrances and flavors maker Quest International; oleochemicals producer Unichema International; and Crosfield, a maker of inorganic silica- and alumina-based compounds.

With myriad products even within specialty categories, it is no wonder that chemical companies that once thought they could encompass all salable economic disciplines within the confines of one company are choosing to specialize. Although ICI separated itself from the fine chemicals and pharmaceuticals business and now prefers specialty chemicals, Hoechst, Monsanto, Rhône-Poulenc, Ciba-Geigy, and Sandoz have chosen to focus on life sciences.

The current reformation of some large, diversified chemical manufacturers into focused chemical groups is a bit like a game of three-card monte. The object

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Photo by David Hanson

Jean Bélanger, president of the Canadian Chemical Producers Association, convinces his board of directors to approve a program that will become Responsible Care.

BASF's Ludwigshafen, Germany, complex, which covers more than 1,700 acres, employs more than 44,000 people who develop, test, produce, and sell more than 8,000 different products.

is to determine who owns which assets as the firms reinvent themselves and continue to globalize their operations.

Hoechst, which acquired the U.S.-based Celanese operations in 1987, is now prepared to separate from its Celanese basic chemicals and acetate company and other units so that Hoechst can concentrate on its agricultural and pharmaceutical life sciences businesses. Ciba and Sandoz combined their life sciences businesses to form Novartis in 1996. Ciba's specialty chemicals business has retained the Ciba name. Prior to the merger with Ciba, in 1995 Sandoz spun off its dyes and specialty chemicals business into a company called Clariant. And last year, Clariant acquired Hoechst's specialty chemicals operations.

Also last year, Monsanto engineered a split into two companies: a life sciences company that retains the Monsanto name, and a chemical company now called Solutia. Rhône-Poulenc is separating its chemical business, including large U.S. operations, into a new company called Rhodia in order to concentrate on its life sciences sector, which includes the U.S. pharmaceutical company Rhône-Poulenc Rorer.

Dow and DuPont continue to survive as broad-based chemical companies.

Responsible Care to the rescue

Ten years ago, the Chemical Manufacturers Association (CMA) launched its Responsible Care program. "It gives the public our commitment to continually improve health, safety, and environmental performance," says Frederick L. Webber, president and chief executive officer of the 200-strong group of companies that represent 90% of U.S. basic industrial chemicals production.

The idea for and basic outline of the Responsible Care program originated with the Canadian Chemical Producers' Association (CCPA). In the early 1980s, then-CCPA president Jean M. Bélanger convinced his board of directors they had to find a way to deal with public environmental concerns. Accidental chemical spills and increasing regulations caused many producers to fear they would lose the flexibility they needed to operate, Bélanger has said. Even before the 1984 accident in which a lethal cloud of methyl isocyanate leaked from a plant partly owned by Union Carbide in Bhopal, India, and killed thousands, CCPA had adopted guiding principles for the installment of a Responsible Care program.

In the U.S., the Bhopal accident provided the impetus U.S. chemical makers needed to adopt the Canadian example. CMA started with a voluntary effort, the Community Awareness & Emergency Response program, to provide emergency planning coordination between a plant and the nearby community. That program became the first of six mandatory codes of management practice at the heart of Responsible Care. The other codes require companies to practice pollution prevention; to adapt process safety in order to prevent accidental releases from a plant; to reduce hazards in the distribution, transportation, and storage of chemicals; to train employees in ways to reduce health and safety risks; and to take responsibility for the safe handling, distribution, sale, recycling, and ultimate disposal of a chemical product.

Adherence to all facets of the program is now an obligation of membership in CMA. Another element of Responsible Care is an independent public advisory panel that counsels CMA on the effectiveness of the program and its further development.

A recent enhancement of the Responsible Care program is a voluntary verification protocol for management systems. This verification protocol brings together a team of examiners from other chemical companies, and from third-party community representatives, carriers, and distributors. Under the leadership of a paid contractor, the group reviews how well a plant site has adapted the Responsible Care ethic—from senior managers at corporate headquarters to line operators.

Canada and the U.S. are not the only countries to have adopted Responsible Care. The International Council of Chemical Associations, an international organization of chemical manufacturer associations, reported in 1996 that Responsible Care had been adopted in 40 countries, thus bringing 86% of global chemical production under the umbrella of the program.

J. Lawrence Wilson, a past CMA chairman and chairman and chief executive officer of Rohm and Haas, says the U.S. chemical industry has indeed gotten the Responsible Care gospel: "We've learned to look up from our lab benches, reach out beyond the plant gates to neighboring communities, and find ways of linking up with others across the oceans and around the world to join in making this planet a better place to live."


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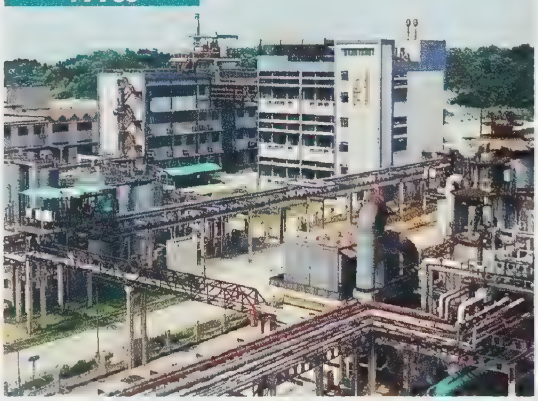
Joint-venture plants in Asia—like this polystyrene plant in Nanjing, China, built by BASF and Sinopec Yangzi—are seen by global chemical companies as a way to tap the large Asian market.

1990s



1995

Women's disease claims force leading silicone gel breast implant maker Dow Corning—a joint venture of Dow Chemical and glassmaker Corning—into bankruptcy.

While pursuing large markets for their chemical products, both companies have also focused on the life sciences business. Dow did sell its Marion Merrell Dow pharmaceuticals business to Hoechst in 1995. However, it bought out its partner Eli Lilly in the agricultural biotechnology and life sciences company DowElanco last year and took a majority position in Mycogen, a developer of genetically enhanced crops and biopesticides.

DuPont has separated its pharmaceutical businesses in the DuPont Merck Pharmaceutical alliance but has beefed up its own interest in agricultural biotechnology through the formation last year of a research alliance with Pioneer Hi-Bred and the purchase of Protein Technologies from Ralston Purina. Both the Dow and DuPont focus on biotechnology, as well as pharmaceutical companies' interest in the technology, dates to the discovery of recombinant DNA technology in the 1970s.

Biotechnology

U.S. government investment in basic biomedical research in the late 1970s and early '80s led to the development of biological techniques to produce new pharmaceuticals and detect human disease. These new genetic manipulation techniques found their way into other disciplines and led to the development of pollution-degrading microbes, herbicide-resistant plants, and a host of other potential new products.

Venture capital available from U.S. entrepreneurs and the investment arms of U.S. chemical firms led to the founding of hundreds of small companies dedicated to developing products using biotechnology techniques. Among them were Chiron, Cetus, Biogen, Centocor, DNA Plant Technology, Calgene, and Crop Genetics.

A number of biotechnology firms have already introduced commercial biotechnology products. Among such companies are Amgen, which introduced erythropoetin in 1989 for anemia resulting from dialysis, and granulocyte colony-stimulating factor in 1991 to mitigate chemotherapy treatment effects. Genentech introduced its Activase tissue plasminogen activator in 1987 for myocardial infarction and human growth hormone in 1985 to treat children with physical development difficulties.

The activity in biotechnology has attracted a large number of U.S. and European pharmaceutical companies. For instance, Hoffmann-LaRoche bought a controlling interest in Genentech in 1990. In 1989, American Cyanamid (now part of American Home Products) acquired biotechnology vaccine developer Praxis and, in 1992, a stake in Immunex. American Home Products has recently acquired Genetics Institute.

Biotechnology investments in agricultural products have also had some success. Monsanto received government approval to sell recombinant bovine growth hormone in 1994 to increase cow milk production. And Monsanto has developed a number of herbicide-resistant crops, including soybeans and cotton resistant to its Roundup herbicide and potatoes resistant to the Colorado potato beetle because they contain a gene capable of producing the insect toxin from *Bacillus thuringiensis.*

The interest of many large firms in biotechnology techniques promises many new products for the future. Some hope to extend their use to the production of what are now considered industrial petrochemicals. DuPont, for instance, says it is developing an enzymatic process to manufacture 1,3-propanediol.

A global industry

Without a doubt, companies engaged in the chemical enterprise will take additional twists and turns as they confront new issues. As Saudi Arabia's Saudi Basic Industries Corp. expands its position as a producer of petrochemicals with a seemingly inexhaustible supply of oil and gas feedstock, U.S. and European companies may have to shift strategies in the future. One route many European and U.S. companies are taking is to move production to the developing countries of Asia.

Many Western companies made relatively small investments in Asia, Eastern Europe, and Latin America before liberalization of trade with China in the late 1980s and the breakup of the Soviet Union in 1991. But they now have major investments in these regions. No more is economic ideology—along with language and culture barriers—the excuse for a firm centered in the U.S. or Europe to not invest outside traditional markets.

Dow Chemical, for instance, has made a massive investment in the development of the Buna Sow Leuna Olefinverbund chemicals site formerly run by the now-defunct communist East German government. The collapse of the Berlin Wall in 1989 and the reintegration of the Germanies have opened trade and development possibilities. Dow sees eastern Germany

Hüls photo

1990s

Paints and coatings for products such as automobiles are an important sector of the chemical industry that is coming under increasingly strict regulation for emissions.

1990s

Genetically engineered agroproducts—such as Monsanto's cotton, altered to be insect resistant (left)—are used by U.S. farmers.

as an entry into markets cut off from most trade with Western firms, as do others such as Solvay, Akzo, and Hüls.

These and other firms are also investing in South America, where governments have newly liberalized trade and investment rules. For instance, Eastman Chemical has made large investments in Mexico for polyethylene terephthalate bottle polymer. Dow Chemical bought a controlling interest in Estireno do Nordeste in Brazil, making Dow the largest South American producer of polystyrene, and ICI gained a sizable foothold in the South American paints business with the purchase of Brazil-based Bunge Paints.

The greatest investment activity over the past decade, however, has been in Asia-Pacific countries. Many U.S. and European companies have rushed into Asia to take advantage of growing markets and opportunities they see in countries such as Singapore, Malaysia, and Indonesia. Dow Chairman William S. Stavropoulos estimates that "55% of global economic growth will take place in Asia over the next 10 years." Dow has made plans to continue its growth in Asia and recently opened plants in Thailand and Indonesia.

In Singapore, a joint venture between a unit of Royal Dutch/Shell and 57 Japanese companies operates a huge ethylene and propylene complex. Mobil and Exxon are considering placing ethylene facilities on this small island city-state. Here, DuPont has made its second largest investment in Asia—after Japan—with polyacetal, nylon, and adipic acid facilities in place. German chemical producer BASF moved its world headquarters for its textile, leather chemicals, and dyes business to Singapore.

In Indonesia, the petrochemical industry has grown from one or two plants operating on the Merak Peninsula west of Jakarta in 1990 to more than 40. U.S. and European firms are active in the country, with BP Chemicals, DuPont, Amoco Chemical, and Arco Chemical constructing new plants. Japanese investors are very active in the area, too. A joint venture of Mitsubishi Chemical and a local group, Bakrie Brothers, produces 1.3 billion lb annually of purified terephthalic acid there.

And China, largely closed to Western trade until the late 1980s, has become a particular favorite of Western companies' investment. Despite a lack of infrastructure and clear operating rules, Western companies have invested large sums in China. They have started wholly owned operations in some cases, but more often they form joint ventures with Chinese chemical firms. Bayer has recently opened a pharmaceutical plant in Beijing. Together with Chinese companies Sinopec and Yangzi Petrochemical, BASF is planning a massive ethylene and derivatives facility in Nanjing. And with DuPont, BASF plans to build a nylon intermediates venture with facilities likely to be built in China.

Despite the currency crisis in Asia in late 1997, particularly affecting Thailand, Malaysia, and South Korea, most Western chemical firms and local producers remain optimistic about long-term prospects for their industry. Although it's likely that few consumers in Asia are familiar with DuPont's one-time slogan, "Better things for better living through chemistry," many are seeing it in action.

Asia, Latin America, and Eastern Europe are at a point in their economic and industrial development at which most would have to acknowledge the improved quality of life chemical products make possible. But most consumers in already industrialized nations are well past the stage when each new chemical advance is a marvel. And most people living in industrialized countries are well aware of the environmental risks that accompany a higher standard of living.

Current development of "green chemistry" processes that turn out zero waste, that rely on recycling usable content of goods past their service life, and that extend biotechnology techniques to the production of what are now considered industrial petrochemicals hold much promise for the future. Perhaps they will reprise the role for the future that the development of petroleum-derived chemicals played in the 1930s.

In fact, some of the old techniques are being revisited today for the promise they hold in the future. Where petrochemical sources of such products as industrial ethanol have displaced fermentation techniques, the biotechnology industry uses fermentation to cultivate drug-producing microorganisms. And interest in utilizing coal in a clean and efficient manner to displace petrochemical feedstocks was revived with Eastman Chemical's start-up in 1983 of a coal-to-acetyl chemicals plant in Tennessee.

In both developing and developed countries, DuPont's promise still rings true. Chemists and chemical companies do not have all the answers today. But their collective know-how has fueled a chemical enterprise that has improved the quality of life over the past 75 years.◀

Changing Priorities Drive Progress In Education

Today's chemistry student is different from the student of 75 years ago, and educators have responded

Linda R. Raber
C&EN Washington

The entry of different kinds of students into chemistry over the past 75 years has produced both opportunities and challenges for educators and students at all levels. Changing national priorities and increasing college attendance have led to an influx of students with expectations and attitudes sometimes radically different from those of their professors. The changing student population has led to different approaches to teaching chemistry, controversy about doctoral training, the growth of interest in how students learn best, and for some, an almost wistful longing for the good old days.

There are more students in college chemistry today, but only about 3% of students who take a general chemistry course end up majoring in chemistry. Today, chemistry students in the U.S. are not all—nor even predominantly—male, they are not all between 18 and 22, they are not all middle class, they are not all white, and they are not all American.

Many college chemistry students are typical independent Generation-Xers, people who are energized and motivated by completing projects—like chemistry classes or bachelor's degrees—yet are restless and impatient in class. They are savvy consumers of education and look to their professors to serve them. Many have a very clear idea of where they want to be when they get out of college, and they don't want to have to deal with any extraneous details. They want the relevance of their studies to be made clear up front.

Depending on who is talking, teaching these nontraditional—as well as the more traditional—students is challenging, exciting, frustrating, uplifting, or depressing. "All of these things make for a very, very interesting fabric of the profession," says Derrick Tabor, professor of chemistry at Johnson C. Smith College in Charlotte, N.C. "The only constant that there's ever going to be is continual change." Perhaps, it's the only constant there ever has been.

Early this century

By the turn of the 20th century, the education of Ph.D. chemists through research was well established. Modern research laboratories became the training grounds for doctoral-level chemists in the U.S. starting in the 1870s. In 1876, Ira Remsen established the most well-known of these chemistry labs at Johns Hopkins University in Baltimore. These and the other academic labs that soon followed became the major source of the nation's scientific leadership in the early 20th century.

These laboratories were dedicated to the pursuit of pure scientific knowledge untainted by concerns about industrial applications or profits. Remsen himself was a champion of the pursuit of scientific knowledge for its own sake and was known to stress the "morally uplifting value of graduate education." To Remsen and many of his contemporaries, pure science was the key to understanding nature, the model for all forms of learning, for civilized behavior, and for human progress.

But his graduates and their graduates were well trained in research and began to make discoveries that could be commercialized. So it was only natural that they became very much in demand by a rapidly growing U.S. chemical industry.

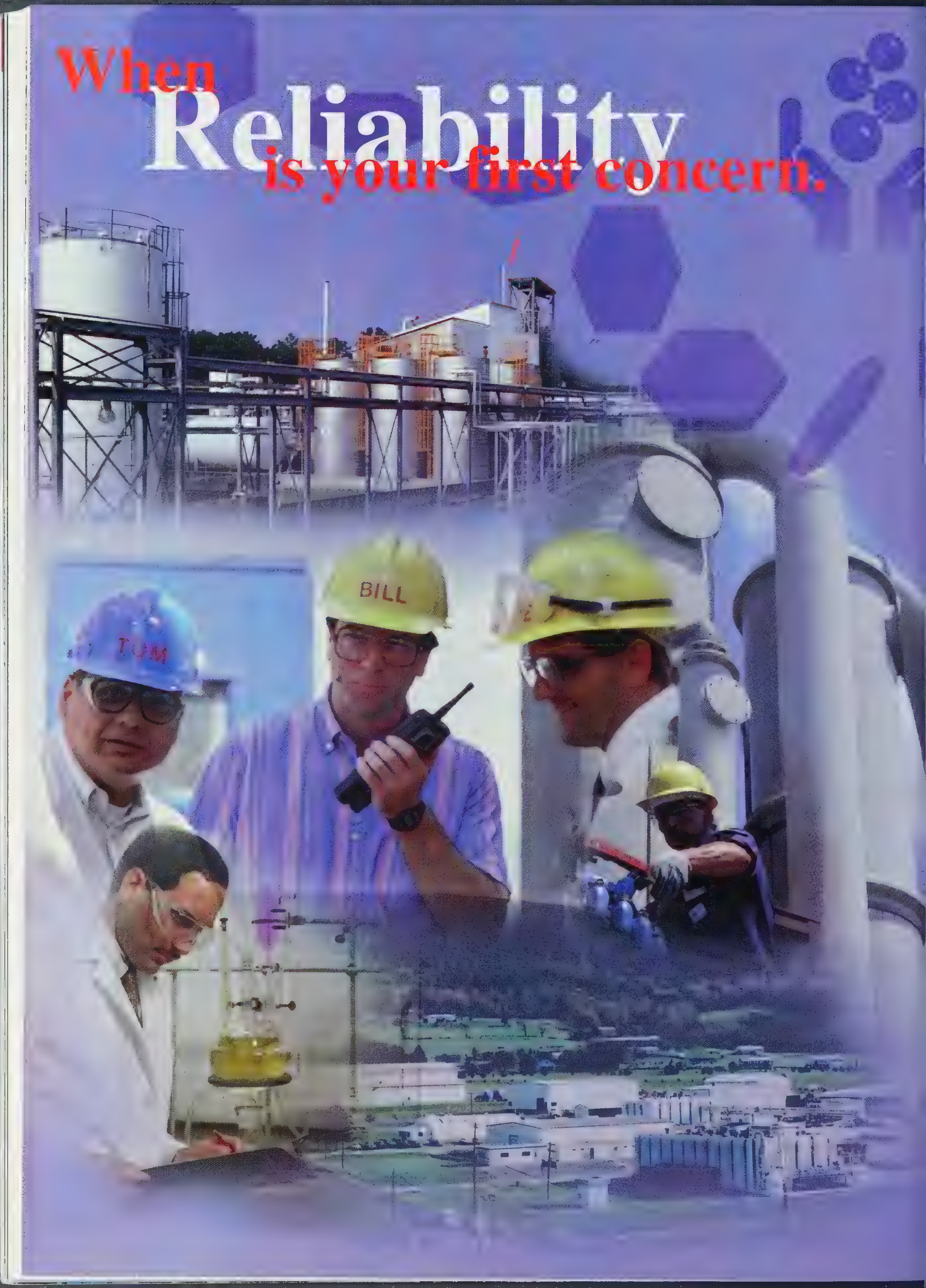
In the early 1920s as today, *Industrial & Engineering Chemistry News Edition,* the predecessor to *Chemical & Engineering News,* was reading the pulse of the chemistry community—academic and industrial. Its pages frequently featured lively commentary and letters discussing the appropriate nature of chemistry study and of who was and who was not qualified to call themselves a chemist. Already, there was some tension in the air.

"A degree is like a patent of nobility," read a 1923 letter to the editor. "And those who have one resent the entrance of some plebeian upstart into their class." Nevertheless, enter they did. Increasing numbers of students began to look toward the chemical industry as a place to pursue their futures, support their families, and maybe make enough money to be comfortable.

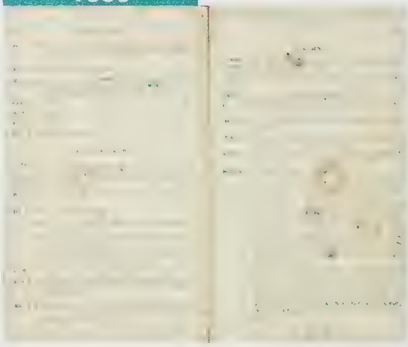
Some of the 1920s' old guard found this pragmatism a bit wrongly focused. And some invoked as ideal an image of a worshipful student who stayed in school, getting all of the degrees he could get. "The three years of study at the feet of a master . . . cannot be replaced with twice that time spent working in an industrial laboratory," argued another correspondent in a 1923 letter to the editor of *I&EC News Edition.*

The writer continued, "Many a man can work out his own salvation without help, but let us keep our science of chemistry on a high plane." Then he added: "I have always felt that there are too many self-made and half-baked chemists, so called, on the market today. . . . Encourage the young men to get all the degrees they can before they begin work if we wish to make any real advances in chemistry."

But some just wanted to get on with


When
Reliability
is your first concern.
BILL
TOM

1880



“Qualitative Analysis: A Guide in the Practical Study of Chemistry,” containing mostly descriptive chemistry, is published. Shown here, pages on sulfuric acid and chlorine, which likely got too close to the lab bench.

1893

At the University of Pennsylvania, Edgar Fahs Smith is already instilling in his pupils the principles of basic research.

1901

Elijah P. Harris lectures on carbohydrates at Amherst College.

their lives, as relayed by chemist E. Randolph Fawcett, in a commentary in a 1924 issue of the magazine. He wrote:

“Recently a discussion among a group of high school boys as to the college courses they expected to take, in preparation for their life work, proved not only interesting but enlightening. The majority were planning on some form of engineering. One lad finally said, ‘No, not for me. Commerce, business, law, psychology. Four years in college is long enough. Then two years and get married with a home of my own.’

“This [response] was so unusual that I asked for his reasons,” Fawcett continued. “The student replied, ‘My cousin took a complete course in chemistry, seven years, and found that in spite of all that training, he had to begin at the bottom and work up. It will be years before he will be able to support a family and a flivver [an automobile].’ ”

Fawcett pressed on, “Isn't that true of any profession?” The boy replied, “In a way, yes, but in chemistry you have to wait for the old ones to die before you get anything worthwhile. Even then the businessman is far ahead.”

During the years following World War I, the chemical community, led by the members of the American Chemical Society, launched a public outreach campaign to convince the country to support chemistry. And students eager to enter the burgeoning dyestuffs and pharmaceutical industries flocked to chemistry in droves.

New knowledge in the areas of chemical bonding and thermodynamics forced students to get a broad background in foreign languages, physics, and mathematics to keep up in class. In addition, big lecture-hall demonstrations were giving way to extensive laboratory work. Students were becoming more personally involved in the hands-on aspects of chemistry earlier on in their education.

This increased demand for chemistry courses resulted in dramatic growth in university chemical engineering laboratories. In addition, chemical education itself began to be an area of increasing interest. Several ACS programs of very long standing have their roots in the years between World War I and World War II.

In 1924, the Section of Chemical Education of ACS started the *Journal of Chemical Education* as a source of information for chemistry teachers across the country. In 1936, the ACS Committee for Accrediting Educational Institutions (now called the Committee on Professional Training) developed, for the first time, minimum standards for the chemistry curriculum. The next year, 1937, ACS started its student affiliates program, the preprofessional program for undergraduates, to encourage and support students in their pursuit of a chemistry education.

Postwar years

The return of veterans after World War II and the G.I. Bill created a tremendous rush of students into universities. Although he was still in college at the time, Washington State University chemistry professor Glenn A. Crosby watched what happened when that bulge of students came through the colleges and then went to graduate school. “Graduate schools suddenly exploded with people,” he says. “There was a huge enrollment. As a result, the requirements for going to graduate school were very high. You had to have very top grades, top everything,” he recalls.

In addition, after World War II, there was a profound shift of the U.S. economy from traditional industry into one that would build its future on sophisticated exploitation of advanced scientific knowledge. The biggest acceleration in this shift came from the military preparedness effort, which was thrust into even higher gear after the Soviet launch of *Sputnik 1* in 1957.

A lot was at stake. Faith in science, the nation's security concerns, and competition with the Soviet Union blended scientific pursuit with patriotism. And the government was supporting science in a big way. Passage of the National Defense Education Act in 1958, for example, was a direct response to the Soviet *Sputnik* launches and resulted in a surge of government funding for graduate students and university research.

“When I went to college, I didn't know what I wanted to be. I loved science and I had this yen to learn things,” says Crosby. “When a professor walked up in front of the class and started lecturing, he was on a pedestal to me. I wanted to know more or at least as much as that person. They had Ph.D. degrees, and I admired what they had achieved.

“That was the culture of those of us who sat in the classroom,” he explains. “We had a certain amount of reverence, a certain amount of respect that we gave

1905

A Massachusetts Institute of Technology chemistry class poses for posterity.

1922

Ira Remsen, pictured here five years before his death, ran a famous academic research laboratory at Johns Hopkins University, beginning in 1876.

George Pimentel, one of the nation's leaders in chemical education and a leader of the CHEM Study project.

1958

those people who had Ph.D.s and knew a great deal more than we did, and we wanted to get that."

The attitudes of chemistry students, like all people, reflect the society of the time. "By the end of World War II, we believed everything the politicians told us," explains Diane Bunce, chemical education researcher and professor at Catholic University of America, Washington, D.C. "We believed everything we heard on the radio, and then eventually everything we saw on TV." It wasn't until some years later that the wholesale questioning of U.S. institutions got under way.

California State University, Los Angeles, chemistry professor Stanley Pine agrees. "In the 1950s, our society was much clearer. It was very clear to everybody about what they needed to do to get where they wanted to go. Now our society is much less clear, which means that students are much less secure."

The late 1960s and early '70s were transforming and traumatic for American society. The Vietnam War; the assassinations of John F. Kennedy, Martin Luther King, and Robert F. Kennedy; the riots at the Democratic National Convention in Chicago; the killing of students by National Guard soldiers at Kent State University; and the break-in at the Watergate that resulted in the resignation of President Richard M. Nixon, to name just a few wounds the country endured, threw the whole fabric of society into question. Students played an active role in much of the social change and began to demand more freedom.

Simultaneously, student preparation for college chemistry began to fall off. "You could see that happening," says Crosby. "The students' abilities in simple arithmetic were falling. We have never really recovered."

On a chemical arithmetic exam administered to all students entering Washington State University, the performance of the students fell 16% in the five years between 1969 and 1974, whereas the grade point average of the incoming freshmen had increased 5% over the same period.

"I saw that happening," Crosby says, "and, while I don't know what caused it, part of it had to do with more students coming into the university. But I don't think that's all of it. I think there was a cultural change in the high school and there was more grade inflation."

Crosby and many others believe that the decline in student preparation continues today. He thinks that part of the reason may be that high school teachers are underprepared. But even that doesn't tell the whole story.

"Over the years since the 1970s," chemist J. Ivan Legg, provost at the University of Memphis, says, "we've learned that the issue is much more complex than just teacher preparation. The student mix we get now is much different than the student mix in the 1950s. In the 1960s, we started drawing students in large numbers from economically disadvantaged communities. And as a result, we were getting students who were even more poorly prepared. And yet we were compelled to recognize that we had a much broader citizenship than the traditional one we had before, and we had to do something about it."

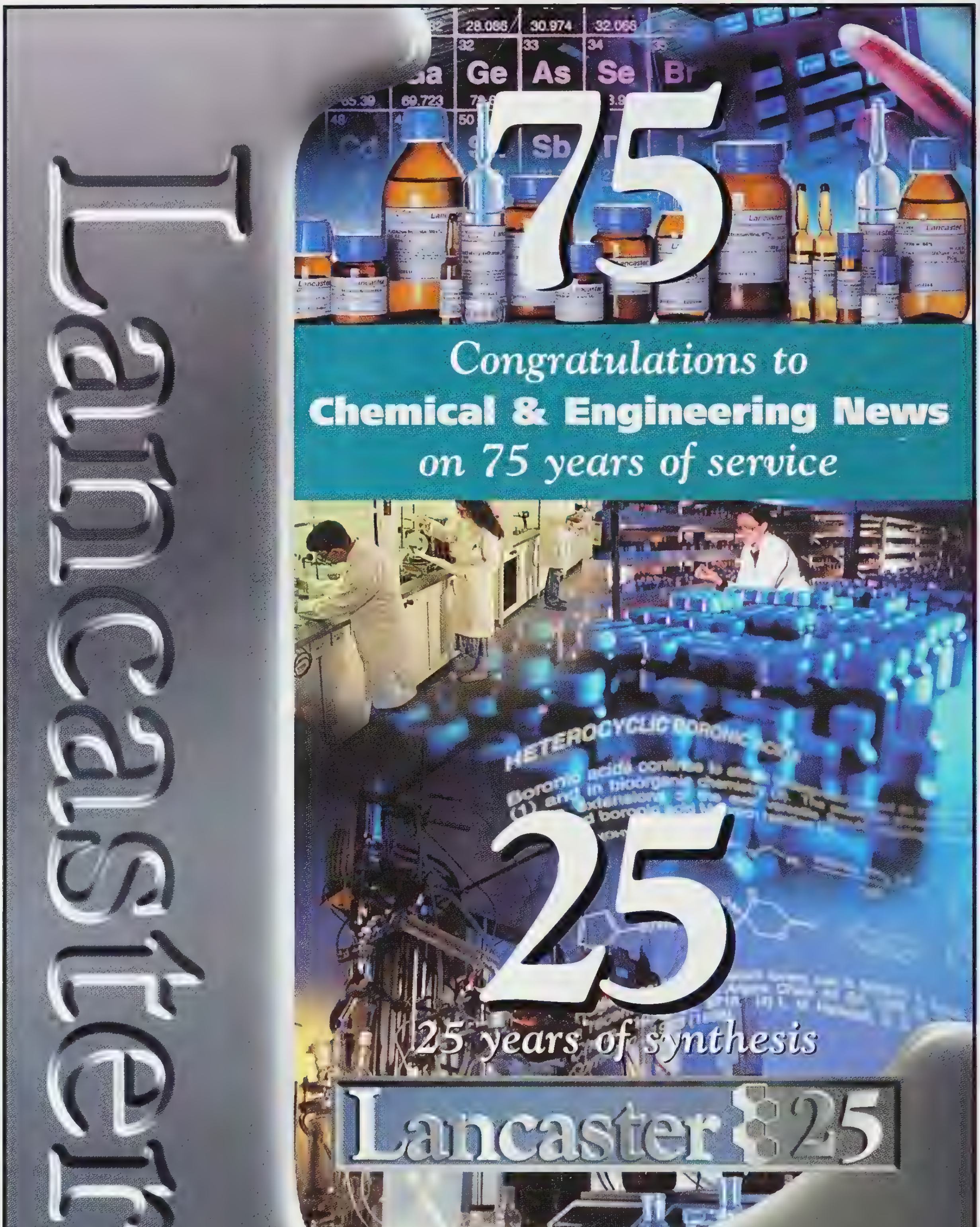
Different learners mean different learning styles and different backgrounds. "It used to be that with almost anyone who was taking physical chemistry, you could count on a good grounding in calculus, in organic chemistry. Now, you can't count on anything," says Crosby. And it seems neither can students, not even those earning Ph.D.s.

Ph.D. education

The traditional model of graduate education at the doctoral level, organized around an intensive research experience, has been the mode of education of Ph.D. chemists since Remsen's time and has served as a world pattern for the advanced training of scientists and engineers.

It came about during a time of growing industrial demand for research, and it was strengthened by the national security demands of the Cold War. In addition to security concerns, domestic and global priorities, such as human health and environmental protection, have resulted in a highly developed research infrastructure that has as one of its primary components the education of graduate students.

Demand for scientists and engineers has remained strong compared with other fields, but there has been a marked reduction in demand for traditional academic researchers. This employment situation has already contributed to a frustration of expectations among newly minted Ph.D.s. In addition, major industrial sectors also have reassessed their



CIRCLE 49 ON READER SERVICE CARD

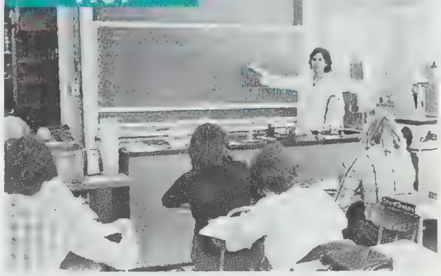
1959

"Chemical Systems" introduces the chemical bond approach to high school chemistry classes.

1974

Students at Washington Technical Institute, Washington, D.C. (now the University of the District of Columbia) study chemistry in the context of food science.

1981



Lynette Miles describes calculations for a laboratory experiment at Broome Community College, Binghamton, N.Y.

needs and reshaped their research, development, and business strategies.

Meanwhile, opinion about what constitutes the appropriate education of Ph.D.s has varied over the years. And the rapidly growing body of chemistry knowledge has made specialization by many Ph.D.s perhaps inevitable, but also worrisome.

"Time was when individual chemists were broadly aware of the developments over the whole of the science," wrote Lord Todd, newly elected president of the International Union of Pure & Applied Chemistry in the Aug. 5, 1963, issue of C&EN. "True, the division of chemistry into organic, inorganic, physical, and analytical sections is of very long standing, but specialists in any one of these used to be on familiar terms with the others.

"But that time has long passed," he wrote, "thanks mainly to the explosive growth of our science during the past 50 years and the fantastic increase in factual knowledge that has accompanied it. The practitioners of the various branches have drawn more and more apart with the passage of time, and only a few years ago, the average organic chemist's knowledge and familiarity with, say, physical chemistry effectively terminated at the undergraduate level."

Concern about the career prospects of these specialized Ph.D. students led the National Academy of Sciences' Committee on Science, Education & Public Policy in 1995 to issue a report, "Reshaping the Graduate Education of Scientists and Engineers." The report says that doctoral programs in science and engineering in the U.S. should better prepare students for careers outside academe. In other words, Ph.D. programs should strive to increase a student's versatility rather than focusing so much attention on narrow areas of specialization.

The report used data collected by the National Science Foundation to compare cohorts of scientists and engineers five to eight years after receipt of a Ph.D. degree (that is, after most of them have completed a period of postdoctoral study). More than half the 1969–72 science and engineering Ph.D.s were employed in universities in 1977, compared with less than 43% of the 1983–86 Ph.D.s in 1991. Only 26% of Ph.D. scientists and engineers were employed in business and industry in 1973, compared with 34% in 1991.

Data for a similar cohort of chemistry Ph.D.s indicate 32.1% were in academe in 1977 compared with only 21.2% in 1991. In government in 1977, about 6% of Ph.D. chemists were civilian employees of the federal government five to eight years after receiving a Ph.D. degree; in 1991, that number had dropped to 2.4%. Business and industrial employment for chemists has increased for that post-Ph.D.-degree period. In 1977, 45.5% were employed in industry; in 1991, 60.9% were.

Those long-term trends led the academy committee to conclude that "Ph.D.s are increasingly finding employment outside universities, and more and more are in types of positions that they had not expected to occupy."

In addition, "employers do not feel that the current level of education is sufficient in providing skills and abilities to the people they are interested in employing, particularly in communication skills (including teaching and mentoring abilities for academic positions); appreciation for applied problems (particularly in an industrial setting); and teamwork (especially in interdisciplinary settings)," the report says.

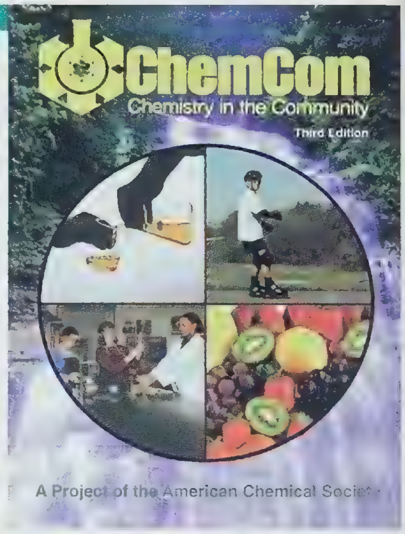
"Over the past 10 years, I believe that Ph.D. preparation has changed," said James D. Burke, manager of research recruiting and university relations for Rohm and Haas, Spring House, Pa., in the May 29, 1995, issue of C&EN. "Savage competition for funding and the need to produce almost immediate results has driven this change. As a result, students seem less curious than before because they have been made to become focused early. I don't see the situation changing much in the near future."

Needless to say, a number of conferences and task forces over the years have tried to determine what elements constitute the essence of the best Ph.D. education. In 1995, then-ACS President-elect Ronald Breslow, chemistry professor at Columbia University, hosted one such conference. Conferees from industry described qualities they found most valuable in prospective employees, and participants from graduate programs described their concerns. What emerged, according to Breslow, was a "remarkable agreement on what doctoral education in chemistry should accomplish and how its goals might be achieved." Achieving a balance between mastery of a specific area of chemistry and gaining educational breadth was listed as the first and, per-

1993

The ACS Student Affiliates Program offers undergraduates the opportunity to present the results of their research at ACS national and regional meetings. Shown here are Rashida McCain of Morgan State University and then-ACS staffer John Higuchi.

1997



ChemCom's third edition, published in 1997, teaches chemistry in the context of contemporary issues. It is now used in 20% of high school chemistry classes in the U.S.

haps most essential, quality of the best doctoral education.

In a 1996 follow-up ACS Comment column in C&EN, Breslow concluded: "We all understand the importance of research and want to minimize interference with it. However, we are educating Ph.D. students for lifetime careers and must see that their education gives them all the skills they need."

Course content evolves

As long as there has been chemical education, some teachers have been looking for ways to make science more relevant to their students. And, to a greater or lesser extent, depending on where you are, teaching methods and subject matter have changed.

An analysis of textbook contents published in a 1924 issue of the *Journal of Chemical Education* shows that McPherson & Henderson, the most commonly used college text at the time, consisted mostly of descriptive chemistry, frequently boiling down to lists of reactions to memorize. It was probably dull. However, a certain amount of drudgery—like a dose of cod liver oil before bed—was considered "good for you."

"A technical student's training is no bed of roses," warned C. A. Brautlecht of the University of Maine, Orono, in a commentary published in a 1923 issue of *I&EC News Edition*. "College men who have succeeded usually admit that some of their college work which was most helpful in developing their reasoning ability was work which was not pleasant while they were doing it. . . . To stay with the lead . . . often requires tact and good judgment on the part of the student. He cannot waste his energy in riotous living and have enough left for the hard courses."

Although he certainly did not advocate "riotous living," Herbert R. Smith, a chemistry teacher at Lake View High School, Chicago, in an article in the January 1924 issue of the *Journal of Chemical Education* asserted that, "Education can be made more attractive and still be dignified. It is not at all necessary to cater to the whims of pupils, but if teaching is to be effective, it must be taught in terms of the subject's service to mankind."

He explained, "Without contact with life, the subject becomes dead to the pupil, and so far as the subject of chemistry is unattractive in the high school, just so far it is taught in a bookish, useless way. The pursuit of chemistry involves just as much daring as any adventure, and its quest as many thrills as any Sherlock Holmes ever discovered."

Textbooks, however, changed very little over the next 40 years. And increasing ripples of dissatisfaction with out-of-date curricula felt by Smith in the 1920s reached a crescendo of self-criticism after *Sputnik*. The atmosphere of the Cold War provided a splendid opportunity for the wholesale revision of the curriculum, noted J. S. F. Pode of Eton College, Windsor, England, in a retrospective published in the February 1966 issue of the *Journal of Chemical Education*.

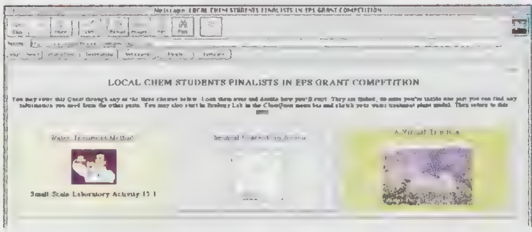
What was wrong with traditional chemistry courses? "Well," wrote Pode, "the courses were too large, built up by a process of accretion, and impossible to finish without a terrible rush." Courses were too factual, and "textbooks had become unreadable encyclopedias of 'essential information.' " Educators also moaned that laboratory work was almost always a tepid demonstration of what the student knew already.

To ramp up the production of scientists, considered necessary to national security during the Cold War, students needed to be drawn into science in high school. So, much effort was spent on revising the high school curriculum. Two fundamental themes that ran through the design of new high school science courses—notably the Chemical Bond Approach (1959) and the Chemical Education Material Study (CHEM Study) courses (1963)—were the continuous development of a limited number of integrative themes combined with the spirit of inquiry—not just memorizing laundry lists of reactions.

The new courses were scientifically and mathematically rigorous. The topics covered in both courses were stoichiometry, atomicity, kinetic-molecular theory, periodicity, energy, rates of reaction, equilibrium, bonding, and acids and bases. The fundamental approach of both curricula was the same—the atom is treated as a unit of structure. "Emphasis in both courses is firmly laid on chemical principles rather than on descriptive chemistry," noted Pode.

Curriculum development is supported by NSF even today, and more and more it is bolstered by research into how people learn chemistry. According to Bunce, chemical education research as a

1997



ChemQuest, a high school chemistry course on the World Wide Web, currently in field-testing, lets students approach a context-based chemistry challenge by using paths of their own choosing.

1997

Loretta Jones of the University of Northern Colorado, Greeley, works with students who use computers to study chemistry.

discipline started gaining steam about 25 years ago. "In chemical education, changes that are focused on the student are now based on the theory of learning by constructivism that says that the student is the focus of the learning, not the professor," says Bunce. "It used to be we talked about the teacher being the 'sage on the stage'; now the teacher is more the 'guide on the side.' "

Bunce was involved with the team that in 1988 wrote "Chemistry in the Community"—or more familiarly, ChemCom, the ACS chemistry course for 10th- and 11th-grade college-bound students. The student-centered pedagogy of ChemCom was groundbreaking. It is now the text used in nearly one in five high school chemistry classes in the U.S. ChemCom paved the way for a growing group of textbooks in chemistry as well as in other disciplines that use a contextual approach to teaching and learning.

NSF is currently funding development of a web-based high school chemistry course called ChemQuest that combines a context-based, student-centered approach to learning chemistry with heavy reliance on computers. ChemQuest is a full-year introductory chemistry course that uses the computer to reconceptualize the learning environment in a highly interactive and inquiry-based design model guided by the new science education standards.

In ChemQuest, the computer has essentially replaced the textbook. All the instruction is on the computer, and students spend about 30 to 40% of their time at computer terminals. The rest of the time they do lab experiments, have discussions, and work on worksheets.

"This is basically college-prep chemistry," says ChemQuest developer Loretta L. Jones of the University of Northern Colorado, Greeley. "But instead of going to class and listening and writing things down and then going home and studying and taking the test, students now come in and have a challenge," she says.

For example, students are presented with a town with water that needs to be purified, and they have to figure out how to purify it. "There is an environmental context in every lesson, and students can either start from the environmental context and then get into the chemistry or dive right into the chemistry," says Jones.

In addition, ChemQuest is adaptable to three different levels of instruction. "In a way, ChemQuest allows students to custom design their own curriculum." Jones says that the course is flexible in such a way that the faster students are not held back by the slower students.

"In many respects, new context-based approaches to teaching chemistry could be considered more rigorous than a traditional chemistry course," says Pine. "We're not asking the students to memorize some simple irrelevant fact anymore; we're asking them to see how this science fits into a social setting."

Different students

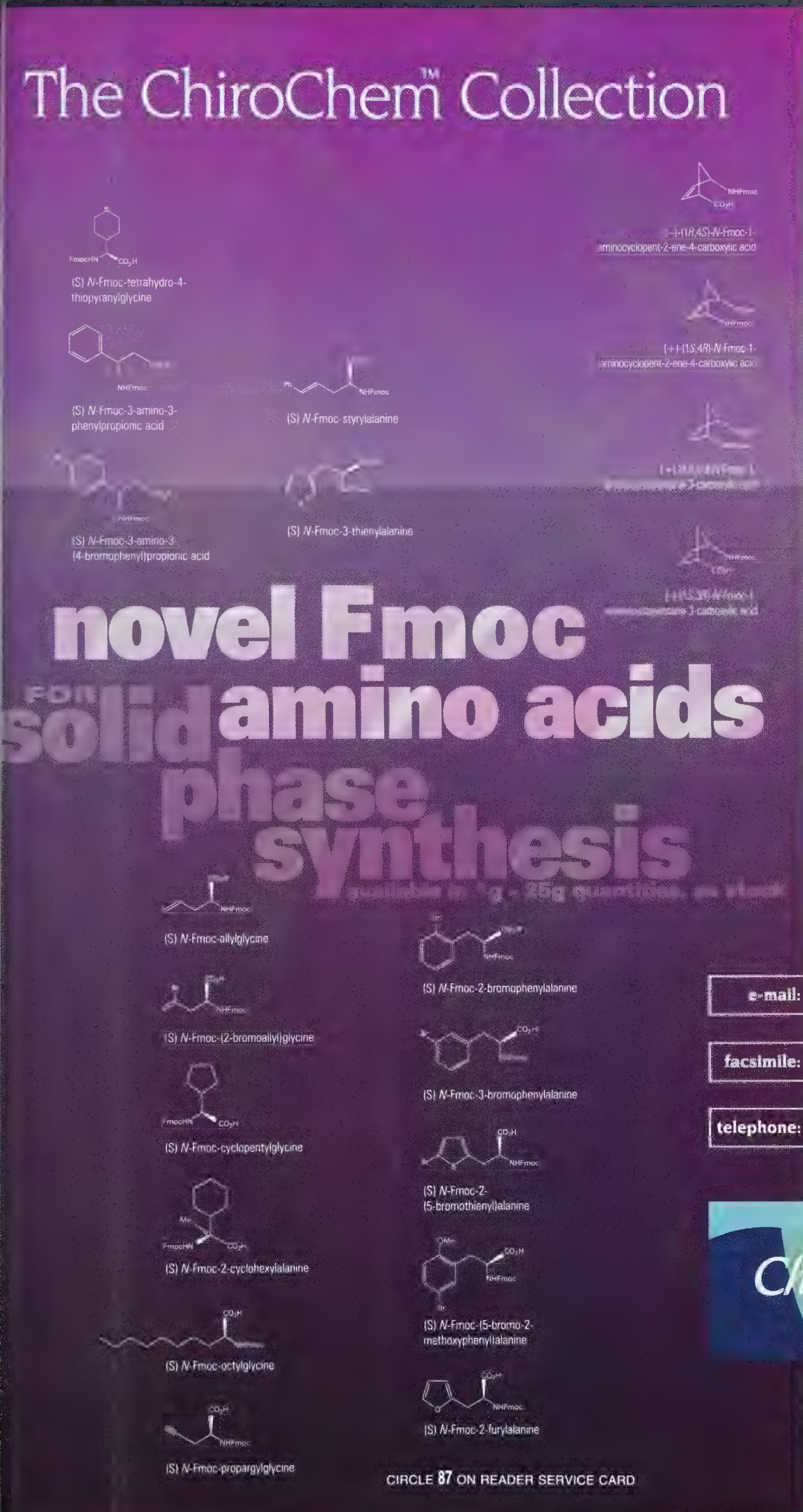
"It used to be that chemistry classes were much more standardized in terms of who was in the audience as well as their backgrounds," says Tabor. "Students' capabilities and their potentials were defined in terms that everybody could agree on. Students either fit or didn't fit some kind of standard mold of what a scientist was supposed to be.

"Now," he says, "we've had to question our assumptions, because . . . the students don't necessarily look like their professors. They don't necessarily come from the same background as their professors. Nor do they study or have the same motivations as their professors. Now the faculty member is challenged with a new type of student."

"Until the late 1960s, higher education was revered, and no one asked a thing about whether we were doing our job or not. No one ever worried about it," says Legg. "There was a whole portion of society that we didn't have to deal with. The economically deprived part of our society was just not part of our agenda in those days. And then we had the Vietnam protests. These protests changed the perception of the universities forever."

Today's students are demanding relevance. They are skeptical and not necessarily in awe of their professors. But skepticism lends itself to scientific pursuit, and diversity almost inevitably leads to creativity.

Legg says: "In any endeavor, you're going to struggle a bit, and the struggle is part of growing. Our diversity is both our greatest strength and our greatest weakness. What makes us as creative as we are is our diversity. This is a rich but difficult field that we have to plow. I'm optimistic, but I think we have some very rough times ahead."◀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FOR solid phase synthesis
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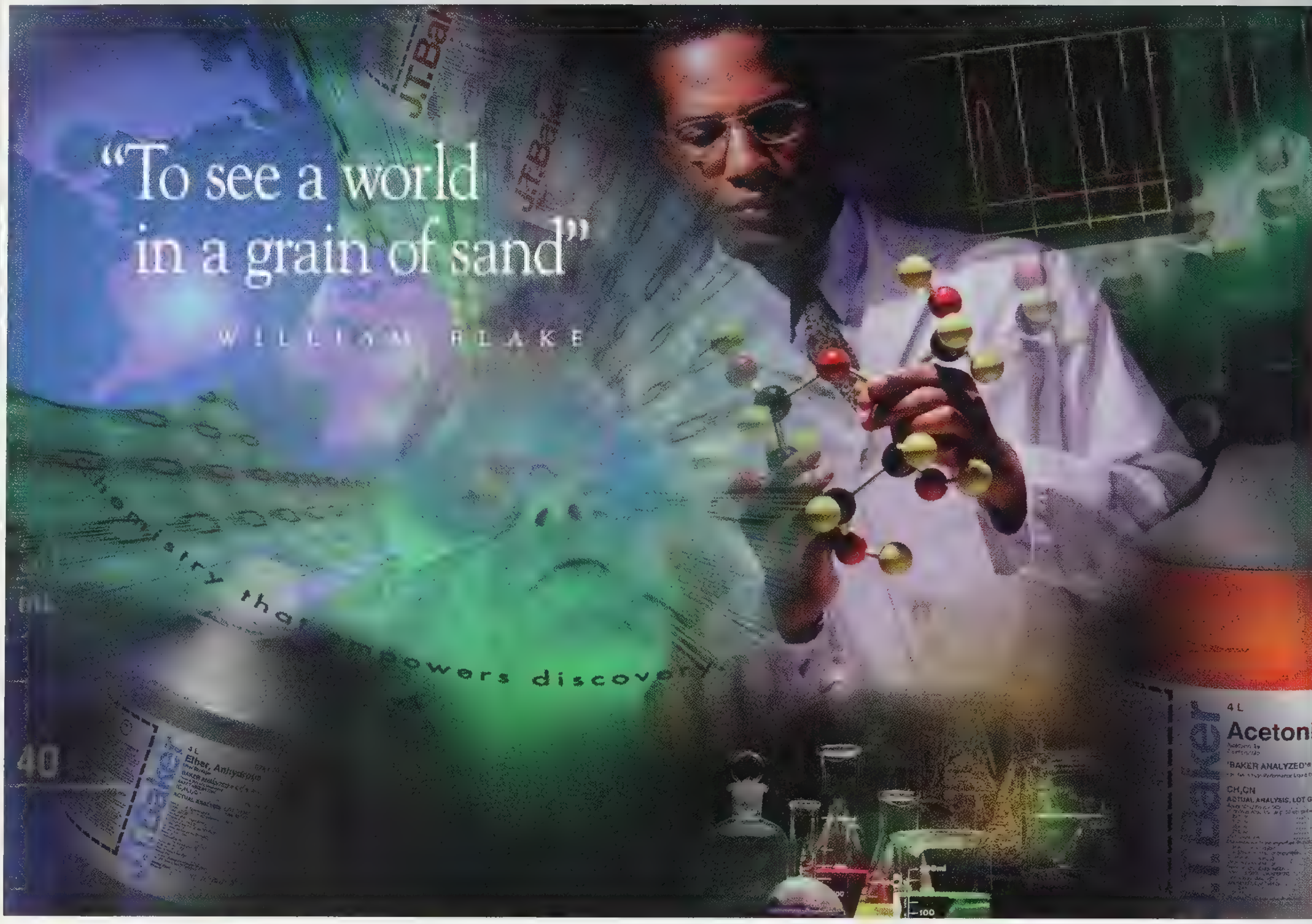

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CIRCLE 52 ON READER SERVICE CARD

The 'Central Science' Seeks A New Contract With Society

Pride by chemists in their myriad contributions is tempered by funding concerns and public misgivings

Michael Heylin
C&EN Washington

Chemistry is more than a science. It is more than even the "central" science chemists claim it to be. It is more than one of the most active, exciting, and productive sectors of the scientific and intellectual frontier. It is more than an important segment of the educational system.

Chemistry is more than a major player in the development of new products and services. It is more than a vital cog in the day-to-day functioning of society. It is more than the chemical industry that is its most direct tangible expression.

Chemistry is also a community. It is also a profession—a way of thinking, behaving, and making a living. Like other communities and professions, it is concerned about its own viability, welfare, and credibility; about its proper role in society; and about its public standing.

A cartoon in the *Cincinnati Times-Star* of Sept. 11, 1930, run at the time of an American Chemical Society meeting in that city and almost a year into the Great Depression, captures the idealized view of the place of chemistry in society. It is captioned "The New Seven League Boots." It depicts a Robin Hood-like figure in tunic and hose striding confidently across the globe, a sword on his hip and a drawstring bag marked "the earth's mysteries" in his right hand. The feather in his jaunty cap is marked "humanity." And his knee-high boots are dubbed "modern chemistry."

This is an image of chemistry that is unchanged to this day, at least in the minds of chemists. It is the image of a vibrant, unfettered science boldly seeking new knowledge while serving society.

However, the enormous pride that chemists have in what they are and what they do has always had a flip side. It is a variety of concerns suggestive of some underlying uncertainties and self-doubts.

These concerns are of two kinds. The first is for the welfare of chemists as individuals—primarily their ability to obtain reasonably secure and sufficiently well-paying positions from which to apply their chemical knowledge in useful, ethical, and professionally fulfilling ways.

The second set of concerns involves chemistry itself. These revolve primarily around a perceived misunderstanding of chemistry by a largely scientifically illiterate public. This is a matter of special concern because taxpayer dollars fund much basic chemical research.

This misunderstanding involves a number of factors, including undue public fear of chemicals stemming from the relatively few negative aspects of chemistry and a persistent distrust of the chemical industry. There is also public disregard for the overwhelmingly positive balance of chemistry's total contributions to society. All this results in chemists having a deep sense of being somewhat unloved and unappreciated, struggling in a pervasive antiscience environment.

The New Seven League Boots

By Claude Shafer, Cincinnati Times-Star, copyright 1930

Chemistry Nobel Laureate Roald Hoffmann of Cornell University "caricatured" (his word) this situation at a symposium at the 1989 International Chemical Congress of Pacific Basin Societies in Honolulu. As he put it: "We [chemists] ain't got no R-E-S-P-E-C-T, respect. We're typed by society, so the complaint goes, as producers of the unnatural, collectively labeled as polluters. We are surrounded by chemophobia, irrational fear of what we do. The media seem to be engaged in a conspiracy against us."

Overall growth

Be all that as it may, the profession of chemistry hasn't done at all badly overall since 1923. The statistics of the major parameters of the U.S. chemical community document enormous growth. But it has been far from a smooth ride. The signs are that the traditional chemical enterprise will remain indispensable and will retain the potential for continuing, solid growth. But its days of truly spectacular advance may be behind it.

However, the role of chemists and chemistry in endeavors with high potential for spectacular growth in the future—but that won't generally be identified as "chemical"—remains limitless. Such areas include the life, environmental, and materials sciences.

Many of the statistics of the traditional chemical enterprise show the classic S-shaped growth curve since 1923. They have an initial start-up phase. This is followed by a period of exponential growth. The third phase is a flattening of the growth curve, indicative of maturity—even if a healthy maturity.

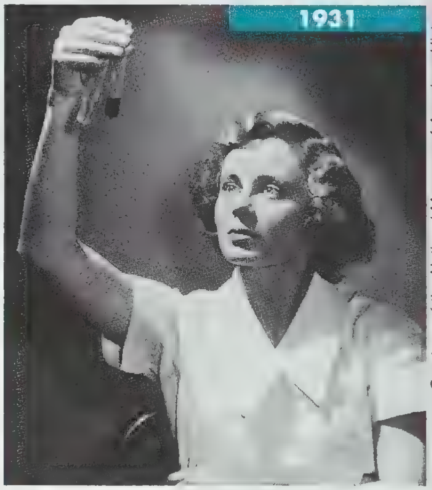
For the chemical enterprise since 1923, these phases correspond with three roughly quarter-century eras. Each reflects societal factors that transcended chemistry itself.

1927

ACS Secretary Charles L. Parsons argues strongly against Geneva Protocol banning use of chemical weapons in war.

1931

Printers' Ink editorial lambasts excessive use of white-coated scientists in advertisements and calls for a "Forget Scientists Week."



Courtesy of the National Museum of American History

The first, from 1923 to 1948, was defined largely by the Depression and World War II. These had the predictable deadening and stimulating effects, respectively, on all things chemical.

The second era, from 1948 until the late 1960s, was a time when the relatively unscathed U.S. prospered greatly by aggressively and skillfully exploiting its economic and technical strengths in a world recovering from the devastation of war and striving to avoid a renewal of global conflict.

The third era, since 1970, is characterized in the U.S. by increasingly tough economic competition from overseas, the downsizing of institutions and businesses as well as of government, and many changes in national priorities following the end of the Cold War. It has also brought greater attention to the environment, more government regulation of industry, and a more critical public attitude toward all government spending, including that for science.

One measure of a profession is the number of people entering it. For chemistry, that number has grown from about 3,300 new bachelor's graduates in 1923 to about 11,000 in 1996. After holding steady at just more than 4,000 per year during the Depression, the number of new graduates grew to more than 6,000 in 1942 before dropping back to the 4,000 level in 1945, reflecting the induction of young men into the military. But—this time reflecting the impact of the G.I. Bill of Rights that financed a college education for returning veterans—B.S. chemistry graduations then surged to about 11,000 in 1950.

The number of new graduates dropped back to the 6,000 level by 1955 as the wave of veterans graduated. Graduations then grew steadily to peak at 12,000 in 1969. This was followed by a drift down to a low of 8,000 in 1991. Since then, the trend has been solidly upward, to more than 11,000 in 1996. Master's and Ph.D. graduations show a similar profile, with major growth between 1955 and 1970 followed by a dip and then a recovery to about the 1970 level in 1996.

Another indicator of the well-being of the chemical profession is membership of its dominant society—the American Chemical Society. Again, the story is a strong one, with ACS claiming to be the world's largest scientific society since overtaking the American Association for the Advancement of Science in membership in the early 1990s.

From 14,300 members in 1923, ACS membership reached 19,000 by 1931 before falling back to 17,600 in 1933. It then enjoyed more than three decades of consistent growth to reach 116,800 in 1969. Then came a slight decline and a flat spot. It took 10 years to move to new higher ground. As a result, growth since 1969 has averaged only about 1% per year. This is a pattern ACS is trying to break out of with a newly launched campaign to boost membership from almost 156,000 today to 175,000 by 2000.

Chemical industry employment shows a similar pattern. It surged from 600,000 just after World War II to reach the 1 million mark in 1967. There has been no sustained growth since then, but it has held above 1 million.

Research and development

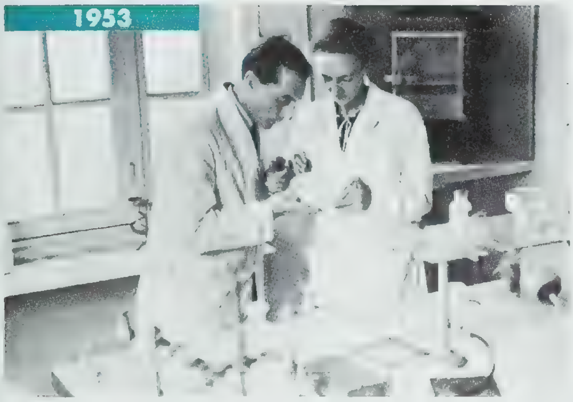
Other statistics of interest to the chemical community are those on R&D funding—especially for basic research. Again, the past 75 years reveal an S-shaped growth curve. After an initial buildup from small beginnings, total national R&D funding—both private and public—grew exponentially during and after World War II. Then came a pause in the 1970s.

Since then, the funding pattern has shifted, with a major drop in defense-related R&D in recent years and considerable gains in civilian-oriented research. There is now renewed growth in most sectors of R&D funding of importance to chemists.

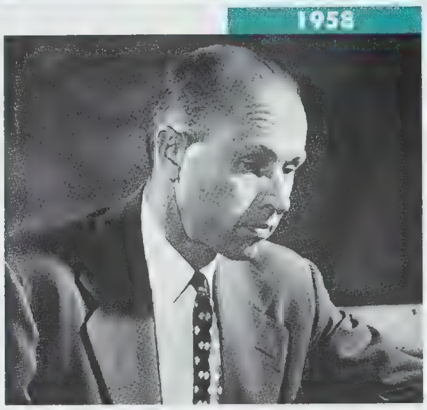
According to National Science Foundation data, total national R&D spending is continuing to grow. The increase in industry spending has more than compensated for the lack of growth in federal funds, which have stagnated at more than $60 billion (in current-year dollars) in recent years. Until 1977, the federal government consistently funded more than 50% of all R&D in this country. This percentage has been dropping ever since—to 45% by 1986 and 34% by 1996.

Estimated total R&D spending—both public and private—of $184.3 billion in 1996 was 15% higher than it had been in 1991. This translates into a 2.9% average annual growth rate for the five years. In constant-dollar terms, the annual increase was 0.7%.

Funds from industry grew from $92.5 billion in 1991 to $113.5 billion in 1996, an average annual constant-dollar increase of 1.9%. C&EN data illustrate some major changes in the source of



ACS denies Nobel Laureate Irène Joliot-Curie, pictured with husband Frédéric, membership in the society on the grounds her science may be suspect because of her communist sympathies.



Eminent chemist George B. Kistiakowsky served in the World War II program to produce the atomic bomb and serves as science adviser to President Eisenhower (1958–60).

these industrial R&D dollars. Between 1991 and 1996, the combined R&D spending of 17 major chemical producers fell, in current dollars, from $2.90 billion to $2.68 billion. Over the same period, the combined R&D spending of six major pharmaceutical companies rose from $4.37 billion to $7.79 billion.

NSF estimates 1996 R&D spending at universities and colleges at $22.4 billion. This was up $4.6 billion, or 27%, over the 1991 level, a 2.7% average annual growth rate in constant-dollar terms.

NSF data also put total spending for basic research at $29.8 billion in 1996, with 51% of it going to universities. This is up by $3.3 billion, or 13%, from the 1991 level. It means no growth in constant-dollar terms for these five years. But the numbers also indicate basic research spending holding at a record level, 33% higher than it was in 1986.

Each year, NSF tallies chemical R&D spending at universities. In 1995, the latest year for which data are available, it totaled $773 million. This was up from $422 million 10 years earlier for an average annual growth of 6.2%. Of these amounts, the federal government provided $535 million, or 69%, in 1995, and $322 million, or 76%, in 1985.

Spending at universities on chemical engineering research has grown even faster, according to NSF. In 1995, it totaled $296 million, with the federal government contributing $161 million. In 1985, the total was $116 million, including $65 million in federal funds.

These indicators of still-high, and in many cases still-increasing, spending on research and development seemingly contrast with the image promoted by the science community of a U.S. potentially at peril in an increasingly competitive technological world due to inadequate science funding.

Such alarm-raising by chemists and other scientists has a long and checkered tradition. At times, it has played a preemptive role in helping to at least moderate periodic attempts to cut back on R&D funding. At other times, it has been conspicuous by its absence, such as in 1995 when Congress came very close to killing a major Department of Commerce R&D initiative. Known as the Advanced Technology Program, it funds applied research projects jointly with industrial firms.

The latest alarm is a petition to President Bill Clinton and members of Congress from the presidents of more than 100 scientific, mathematics, and engineering societies. Organized by the American Chemical Society last October, the petition asks for a doubling of the level of federal investment in research within the next 10 years, starting with fiscal 1999.

Then-ACS President Paul S. Anderson pointed out in a covering letter: "Our nation's technology-based economy has catapulted us to a position of world leadership. The competitive global marketplace, however, has little sympathy for a nation's historic triumphs. The mantle of leadership is not guaranteed by past reputation, rather it must be constantly earned." He continued, "It is for these reasons that we unite to assist and to lead our nation to even greater levels of economic prowess and societal health and well-being."

This initiative is unusual in that it eschews the traditional fighting over the same pot of money rivalries among scientific disciplines and between advocates of basic research and proponents of research of more immediate social relevance. The petition—which triggered a bill cosponsored by Sen. Phil Gramm (R-Texas) and Sen. Joseph I. Lieberman (D-Conn.)—simply calls for an overall doubling of investment in the total federal research effort. It is not specific about what kind of research or who gets what.

Nor does the petition define if the called-for doubling is in current or constant dollars. But either way, as long as inflation remains moderate, it would be a huge boost.

Before World War II, funding for R&D was modest by today's standards. But the highly successful applications of science to warfare—especially the development of the atomic bomb and the successful radar, synthetic rubber, penicillin, and code-breaking programs—changed that forever.

Boosting the explosive power of ordnance 1,000-fold in one bound—and a few years later by another 1,000-fold—earned science very high standing in Washington and with what President Dwight Eisenhower dubbed in his farewell speech the military-industrial complex. It is said that while the atomic bomb ended World War II, radar won it.

This World War II experience firmly established science as something the federal government should continue to fund generously as an important element of economic and national security policy. It remains so today, even as science gropes for a new social contract in the aftermath of the Cold War.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* Test drive our new Gilson 215 and we'll send you a very cool 3-D slide puzzle of the world.
Come to think of it, we'll send you the very cool 3-D slide puzzle of the world just for calling. Test drive or not.

1960

ACS moves into its brand new headquarters in Washington, D.C., during a time of very rapid growth for itself and the entire chemical enterprise.

1962

Publication of "Silent Spring" by Rachel Carson generates vigorous response from the chemical community and helps lay basis for the environmental movement.

The science/society contract

The great flowering of chemistry and the other sciences since the 1940s initially rode the upward wave of a successful working relationship—a contract—between the science community and society.

This wave was given an extra boost by the shock of the Soviet Union's successful launch of the world's first artificial satellite, *Sputnik 1*, in 1957 and the near panic that this generated over the prospect of a U.S. lagging its arch rival technologically in a perilous world. This was a time when scientists were not alone in sounding the alarm over the dangers of an inadequate national R&D effort.

Under this post-World War II science/society contract, research scientists were well supported by federal and private funds, encouraged to explore areas of interest to them, and given a great deal of autonomy. In return, they added enormously to the pool of fundamental scientific knowledge with their curiosity-driven research. In addition, the science community helped exploit scientific knowledge in response to society's most immediate needs—at the time, primarily national defense.

This all led to a quite well defined national science and technology policy. It had the following elements:

- Strong and broad-based funding of basic research plus considerable basic research by industry.
- Strong motivation for industry to exploit scientific developments commercially.
- Establishment of a system of highly capable and well-funded national laboratories.
- Nurturing of a strong university system, especially in the physical sciences.
- Federal funding for scientific developments in areas deemed to be of vital national concern but beyond the means or outside the interests of individual companies—even the biggest. These areas included weapons; aircraft; space; nuclear power; electronics; agriculture; many aspects of public health, safety, and the environment; and—more recently—biotechnology.
- Establishment of administrative and advisory bodies to give science advice at the highest policy-making levels of government and to help handle federal R&D funding, especially for basic research.

It all worked splendidly, at least until the end of the 1960s. According to NSF data, between 1953 and 1968 total national spending on R&D grew, in constant-dollar terms, at an average annual rate of 8.4%—the equivalent of doubling every eight and a half years. The federal government's contribution grew at an even higher, 9.3%, rate. Industry's input, about 35% of the total, grew at a 7.0% annual rate.

Then the wheels came off—at least, for quite a while. Between 1968 and 1975, federal R&D spending dropped 21% in constant-dollar terms, and it would not regain the 1968 level until 1984 with the military buildup initiated in the later years of the Carter Administration and boosted enthusiastically by President Ronald Reagan.

Total R&D spending held up somewhat better, owing to continued growth in industry spending. By 1971, the total had dipped a more modest 7% in constant-dollar terms. It was back up to the 1968 level by 1978.

The impact on the scientific community of this brutally sudden and largely unexpected change from a consistent pattern of 8 or 9% real growth every year to an era of no growth, and even some decline, was profound.

The chemistry community experienced similar trauma during the Depression of the 1930s. The response then—as it was in the 1970s and again in the 1990s—was a variety of efforts to mitigate the downturn's impact on all aspects of chemistry.

These collective efforts were largely expressed through ACS. They reflected both an appreciation and a reminder of the idea that the chemical community must be concerned not only with the well-being of chemistry as a science, but also with the well-being and status of chemists as individuals.

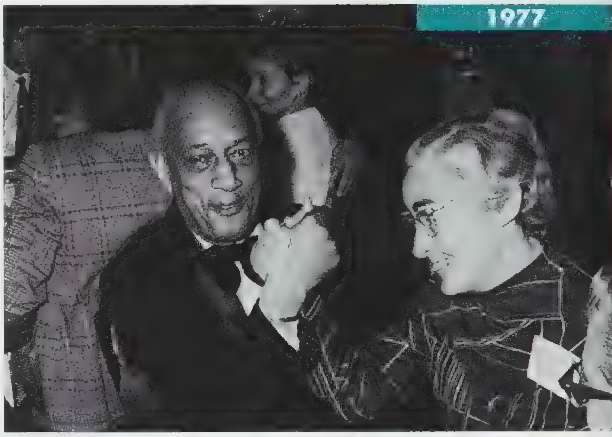
According to a number of observers, the task for the chemical and scientific community today is to develop a new contract with society. With the end of the Cold War, the driving force of the old contract, the incessant demand for the ever more sophisticated weaponry that only science can develop has lost much of its urgency—although weapons development still continues at a historically quite high level in response to a procession of threat scenarios.

Another cornerstone of the old contract is also under scrutiny. This is the belief that there can be no development without fundamental research—that R&D has to proceed in a rigid progression, starting with fundamental research, then moving through applied research, development, engineering, and product development and testing. A growing realization today is that, in the large majority of cases,

1973

Alan C. Nixon becomes the first "professionalism" president of ACS, leaving a mark on society felt to the present.

1977



Henry A. Hill is elected ACS's first, and so far only, black president in 1977, and Anna J. Harrison is elected its first woman president the next year.

these activities behave much more like basketball players—all involved all the time and constantly passing the ball back and forth, each setting the pace at different times.

In addition to the complications such rethinking brings to decision-making about science funding, today's political Holy Grail of a balanced federal budget has made it much harder to sell Congress and the public on the premise that basic research is critically important to the nation because it eventually pays off in unspecified ways at some unspecified future date. With unresolved domestic issues now front and center and with the federal government still putting up more than $60 billion per year for R&D, the pressure is on for federally funded research to be more immediately relevant to the problems of the day.

Era of national trial

From today's perspective, things seem to have been simpler for the chemical community 75 years ago. In 1923, chemists were sitting pretty in this country. They were proud and confident. They had played the central role in the rapid buildup of the U.S. chemical industry triggered by the cut-off of European sources when World War I started in 1914. They had been involved in the effort to supply U.S. forces with the huge quantities of munitions, chemical arms, and other war materials needed after the U.S. entered the conflict in 1917. Many chemists had served in the Chemical Warfare Service and chemists in general took pride in their profession's role in what had become known as the "chemists' war."

The downturn in demand for chemicals immediately after the war was over by 1923. Chemicals, especially synthetic materials, were finding big new markets. The economic boom of the roaring twenties was getting well under way.

This confidence is reflected in a report by two British engineers on industrial methods and conditions in the U.S. (*I&EC News Edition,* Nov. 10, 1927). They wrote: "The industrial workers, the rank and file of [the U.S.] democracy, have attained standards of earnings and comfort and possession and rational enjoyment beyond anything that the ordinary man in this country [the U.K.] conceives. The U.S. presents a spectacle of relative power and confidence, accumulation and economic achievement without parallel in the world's history."

According to the report, the U.S. achieved all this with nine industrial management principles—a listing that, in general, still looks good today:

- Promotion on merit.
- Small profits, large volumes.
- Improvement of processes.
- Time-saving and trouble-saving appliances.
- No limit on possible earnings of any man.
- Exchange of ideas, even among competing companies.
- Elimination of waste.
- Welfare work—surrounding the worker with cleanliness and light, seeking to increase his conveniences and satisfaction.
- Utilization of research.

Another example of this kind of déjà vu in reverse is a letter published in the Dec. 20, 1927, *I&EC News Edition.* It is concerned with public misunderstanding of chemistry. It bewailed unwarranted use of chemical language.

The issue was an advertisement for a new shave cream made from a soap that was claimed to hydrolyze in aqueous solution to a lesser extent than did competitive soaps. The specific complaint was that the advertisement proclaimed, "Don't blame the razor; it's hydrolysis that makes your face smart," and that the nonchemist reader would conclude from this that hydrolysis was a disease. The letter writer goes on, "Lord knows the language of chemistry is not beautiful, but it has its uses and it hardly seems fair to mess the words up with itchings and other human distress."

The high public standing of scientists in the 1930s brought on a protest about their too frequent use in advertisements. A *Printers' Ink* editorial complained: "Can it be that the men who prepare advertising are so lacking in ingenuity, so devoid of originality that they are forced back upon scientists for what seem to them to be good selling ideas? Can it be they are so lacking in clear vision that they cannot see that they are bringing ridicule, not only on science, but also upon advertising itself?" The editorial ended with a proposal for a "Forget Scientists Week."

On a more serious note, 1927 brought an exchange of very blunt letters between Charles L. Parsons, secretary of ACS, and Frank B. Kellogg, the nation's secretary of state. They concerned then-pending U.S. Senate ratification of the Geneva Protocol prohibiting the use of chemical weapons in war.

1984

Photo by Rudy Baum

Double Nobel Laureate for chemistry and peace Linus Pauling receives ACS's Priestley Medal after many years of estrangement from some elements of the chemical community stemming from his political activities.

1984

Photo by Wil Lepkowski

Chemical disaster at a Union Carbide plant in Bhopal, India, sets chemical makers on a path to the Responsible Care program of good operating practice.

According to Parsons, the U.S. should not give up the right to defend itself "by the use of these most effective and most humane instruments." He argued that ratifying the treaty would cause the U.S. to lower its defensive guard and he maintained that should the U.S. agree to a prohibition on the use of gas in warfare, it should insist on strict international policing of chemical industries, including its own.

Parsons concluded, "It is my personal opinion that even such supervision would be entirely ineffective and that there is no possible way to inhibit the use of asphyxiating gases in warfare." For the time, such arguments by Parsons and others prevailed. The U.S. did not ratify until 1975.

The extent of the economic decline during the years following the Wall Street collapse of 1929 is today hard to believe. By 1932, the gross national product had fallen 46% and it did not get back to the 1929 level until 1949. The production index for all manufacturing plunged 48% by 1932. Unemployment, 3.2% in 1929, ballooned to 25% in 1933.

Chemists and the chemical industry were carried along with the deluge. But the impact on them was slightly less severe than on other industries and professions. And the confidence of the chemical community in its role in a better society didn't waiver. An example was a display presented by ACS at the Exposition of Chemical Industries in New York City in 1933. Under the title "Children of the Depression," it showed materials and chemical products commercialized since 1929 as a result of continued R&D.

This faith in chemistry was paralleled by a distrust of government efforts to counter the Depression. At a 1935 meeting of the Manufacturing Chemists Association, as the Chemical Manufacturers Association (CMA) was then known, Lewis Douglas, an American Cyanamid vice president and former director of the federal budget, proclaimed that "New Deal policies, proposed to promote recovery, are having an effect directly opposite to the intended and are driving the U.S. and Western civilization definitely toward communism and the destruction of private property."

At the 1936 Willard Gibbs Medal presentation, Robert E. Wilson of Pan American Petroleum & Transportation Co. stated that, "Probably the most subversive factor in our present situation in this country is the tendency to reduce the incentive for all classes to work hard—the poor man has the alternative of the dole, and the rich man the prospect of excessive taxation if he is able to eke out a profit."

Despite such distaste for collective action, the chemical community aggressively organized itself to help its members—especially those seeking employment—during the Depression years.

The changes that this brought to ACS largely survive to this day, if in slightly different guises in some cases. These 1930s initiatives included the following:

- Change of ACS membership requirements to exclude nonchemists.
- Establishment of a committee on unemployed recent chemistry graduates.
- Establishment of a committee on the professional status of chemists.
- Establishment of a committee to accredit academic chemistry departments.
- Establishment of a student affiliates program.
- Introduction of an employment clearinghouse for each national meeting.
- The first poll of the economic status of chemists.
- Establishment of recommended salary minimums for chemists—an experiment that was dropped when it became apparent employers were interpreting the minimums as maximums.
- Continuation of the active and well-regarded public relations program promoting chemistry that got under way with the ACS News Service in 1919.

These efforts at professionalism were apparently well received by chemists. By 1939, ACS membership was 35% higher than it had been in 1929.

ACS membership continued to surge throughout the 1940s. By 1949, at more than 62,000, it was 165% higher than it had been in 1939. This reflected the greatly increased demand for chemists engendered by the easing of the Depression and the demands of World War II.

An enduring concern of ACS throughout the war was the most appropriate use of chemists in the war effort. The government did not have a clear-cut policy on the induction of scientists into the armed forces. Deferment on the grounds of being involved in vital production work was on a regional, case-by-case basis. As the war progressed and the demand for armed forces spiraled, such deferments became less frequent.

This time, the conflict turned out to be a "physicists' war." But chemists were deeply involved. For example, among the many distinguished chemists work-

1985

Earlier call by Nobel Laureate and 1976 ACS President Glenn T. Seaborg for a total ban on nuclear testing leads to a symposia on the subject at ACS national meeting in Chicago.

1987

ACS launches what is now its annual National Chemistry Week program with a National Chemistry Day celebration.

ing on development of the atomic bomb were Glenn T. Seaborg, George B. Kistiakowsky, and Donald F. Hornig. Later, Seaborg headed the Atomic Energy Commission for 10 years under Presidents John Kennedy, Lyndon Johnson, and Richard Nixon. Kistiakowsky and Hornig became presidential science advisers.

Era of growth

The period from 1949 to the late 1960s presented a unique opportunity for the chemical community to do great chemistry under very favorable conditions and exploit it—as well as the backlog of basic chemical knowledge they had built up during the Depression and the war—to the public good. That's the way things worked out. The one word of career advice—plastics—to the graduate in the 1967 movie of that name, indeed, identified a burgeoning business opportunity.

The immediate postwar period was accompanied by a desire by the chemistry community to minimize anything that might have rocked the boat. The message to chemists was: Stay away from politics and stick to what you know best—chemistry.

Such thoughts were expressed at the American Association for the Advancement of Science annual meeting in Boston in 1954. Kirtley F. Mather of Harvard University said while there was great popular respect for scientists as technicians, there was great skepticism about their ability "in areas of economics, politics, and social organization."

According to Mather, industrial progress and military strength "depend so obviously on the technician that his comfortable niche in the social structure is indefinitely assured." In sharp contrast, Mather believed that continuing support of fundamental research was in a precarious position because it required two things that the climate of public opinion did not then favor—"sizable financial backing and an environment of freedom." This was the McCarthy era.

In 1953, the ACS Admissions Committee rejected an application for membership of the society from Irène Joliot-Curie, cowinner of the 1935 Nobel Prize in Chemistry with her husband Frédéric, on the grounds she was an avowed Communist. In endorsing the action, the ACS Board of Directors stated the Admissions Committee had set no political standards for membership but had said "that those who belong to ACS must be free to think as they wish, to report scientific results as honestly obtained, and to base thereon such theories as can be soundly developed."

Another free-thinking chemistry Nobel Laureate, Linus Pauling, then head of the chemistry department at California Institute of Technology, also ran into political troubles at about that time. As president of ACS in 1949, he had unsuccessfully called on the society to take an activist position on efforts to prevent war. In the 1950s, he campaigned actively for a ban on nuclear weapons testing—an effort that earned him the 1962 Nobel Prize for Peace.

He was branded as a Communist sympathizer by the House Committee on Un-American Activities, and in 1952, the State Department denied him a passport because it said it was not in the U.S. interest for him to travel abroad. All of this led to estrangements between Pauling and some elements within the chemistry community. He left Caltech in 1963 to join the faculty of Stanford University.

Some of these rifts were partially healed many years later. In 1984, ACS bestowed its most prestigious award, the Priestley Medal, on Pauling. In his acceptance speech, he once again called for a campaign to ban nuclear weapons.

The incident that set the tone for much of what has happened since to the chemical community was the publication of "Silent Spring" by Rachel Carson in 1962. It appeared first as a series of three articles in the *New Yorker* and as a book soon after. It raised concerns about the impact of the widespread use of pesticides on the environment, wildlife, and human health.

"Silent Spring" hit an incredibly sensitive nerve for the chemical community, which reacted immediately. Within a few weeks of the third *New Yorker* installment, C&EN had published two editorials, some news items, many letters, and a review of the book.

The Manufacturing Chemists Association immediately formulated an expanded program to win popular understanding of chemicals. And the National Agricultural Chemicals Association (NACA) stood ready to dip into its emergency fund to widen its ongoing information program on the safety of pesticides as well as its "read the label campaign" to help increase proper use of pesticides.

Speaking at NACA's annual meeting just after publication of "Silent Spring," R. H. White-Stevens of American Cyanamid's agricultural division said, "Surely,

Nobel Laureate Roald Hoffmann calls on the chemical community for a more compassionate and understanding approach to public concerns about chemistry.

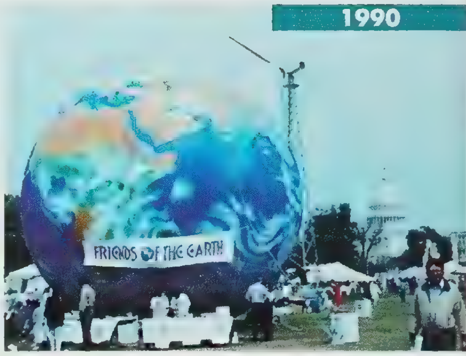


Photo by Richard Seltzer

Exhibits mark 20th anniversary of the first Earth Day—the event that sparked the environmental movement.

she [Carson] cannot be so naive as to contemplate turning our clocks back to the years when man was indeed immersed in nature's balance and barely holding his own." He also urged industry to fire its "ammunition of fact, reality, and scientific truth at the gross misunderstanding of pesticides, which has all too often been punctuated by crises and synthesized sensationalism."

The C&EN review of "Silent Spring"—which was headlined "Silence, Miss Carson"—also had a harsh and dismissive tone. It was written by William J. Darby of Vanderbilt University Medical School, a member of the Food & Nutrition Board of the National Academy of Sciences/National Research Council. Darby's bottom-line recommendation was that "this book should be ignored." But he also stated that "the responsible scientist should read this book to understand the ignorance of those writing on the subject and the educational task which lies ahead."

Darby's review was not universally applauded, and neither was C&EN's overall coverage. In the view of one letter writer, "Instead of [a more] positive type of response to Miss Carson, C&EN and Dr. Darby have reacted like a cigarette company executive when somebody asks if smoking causes lung cancer."

Thirty-six years after her book was published, Rachel Carson, who died in 1964, is still a household name as the spiritual godmother of the movement, sparked by the first Earth Day in 1970, that over the past almost 30 years has permanently changed thinking about the relationships among people, what they do, and the environment.

Forced on the defensive by "Silent Spring," the chemical community is still trying to catch up. A recent biography of Carson prompted critics to renew their attacks; some are still picking through the book looking for flaws. And the tactics of denying problems, dismissing those that are raised, and discrediting those who raise them are being used on some issues relevant to chemistry to this day.

Era of challenge

The slump in R&D funding and the deterioration in the employment status and outlook for chemists during the 1970s brought a range of responses from ACS. Annual polls of ACS members to determine their employment status and salaries were started in 1972.

A code of employment practices was established. It was called the Professional Employment Guidelines (PEG). Among other things, the guidelines spelled out how a chemist should be treated—in terms of severance pay and the like—when fired. An ACS committee examined so-called mass terminations by industrial employers to determine how well they complied with PEG, and C&EN carried news stories on the findings. An effort also was made to help members with specific employment problems on an individual basis. And a program of employment aids was expanded.

The 1970s also brought a level of politicization of ACS that many members thought unseemly for a professional scientific society. This included overt and organized campaigning by candidates for national office and political maneuvering between what became a professionalism wing and a more traditional wing of the society's governance.

Both factions agreed that ACS had to maintain its journals, abstracting services, and other services to the science of chemistry at their traditionally high standards. They also agreed the society had to attend to the professional needs of the individual chemist. The contentions were over the appropriate balance between these two areas and the nature and extent of the professionalism activities.

The first professionalism president was Alan C. Nixon in 1973. Within the next decade he was followed by Bernard S. Friedman in 1974, William J. Bailey in 1975, Henry A. Hill in 1977, and Warren D. Niederhauser in 1984, who won in an election in which his opponent used particularly aggressive tactics that drew attention even outside ACS.

Hill was ACS's first, and so far only, black president. Anna J. Harrison, a political independent, became the society's first woman president in 1978. Only two other women have served as ACS president—Mary L. Good in 1987 and Helen M. Free in 1993.

This period of activism has left its marks on ACS. One is the salary and employment survey, which continues each year. A second is the Summer Education for the Economically Disadvantaged (SEED) program. Started in 1968, it gives high school students the opportunity to spend a summer working in a chemical laboratory. It was ACS's primary social action program until the ACS Board, in 1994, voted to initiate an undergraduate scholars program for minority chemistry students.

For the past several decades, the chem-

Courtesy of Diane Sheridan

A key aspect of the Responsible Care program is the work of community advisory groups in improving plant/community communications.

ACS celebrates 25th anniversary of its successful SEED program to provide economically disadvantaged high school students with summer experience working in a chemical laboratory.

istry community itself has developed increasingly active relationships with government. This is in response to the persistent concern over federal funding, growing interactions between government and chemistry on many fronts, and the need for chemistry to keep telling its own story in the face of continuing assaults.

ACS's role in this effort has been handled by a steadily growing staff operation under direction of the society's governance. In recent years, in addition to funding, there has been much activity on education, patents, and environmental and regulatory matters, including those concerned with working conditions for chemists. In 1974, ACS established an annual fellowship program under which selected chemists can devote a year working with the legislative or executive branches of the federal government.

However, ACS has continued to keep a low profile on defense-related issues. The society finally came out in support of the Geneva Protocol in 1974. It took no part in the many years of negotiation of the complex chemical provisions of the more recent Chemical Weapons Convention and did not support it publicly until August 1996. The U.S. Senate ratified it in April 1997.

ACS got involved briefly in nuclear weapons issues in 1983 when C&EN published a letter from Glenn Seaborg—who was ACS president in 1976—proposing a total ban on nuclear weapons testing. The ACS Board voted against the proposal, but some society members wanted ACS to do something. The issue bounced around the society like a hot potato for some time until Ellis K. Fields, ACS president in 1985, made it a topic of his presidential symposium at the ACS national meeting in Chicago that year.

Reaching the public

Of much more concern to the chemical community over the past 20 or so years has been a constant parade of highly publicized environmental and health issues that have kept chemistry on the hot seat with an increasingly sensitized public.

These have included Love Canal, agent orange, acid rain, the Bhopal disaster, dioxins, global warming, chlorofluorocarbons and the ozone hole, chemically contaminated sites, toxic emissions from chemical and other manufacturing plants, and a long list of specific chemical products including Kepone, Alar, and even chlorine.

A firmly held belief of the chemical community has been that the negative responses these issues engender toward chemistry are due, in part, to the public's ignorance of chemistry. This ignorance is seen as including policymakers. This ignorance is also seen as the root cause of the public's antiscience persuasions.

All this has led to a host of outreach and education activities to present a balanced view of chemistry and to promote the overwhelming positive role of chemistry in society. The National Research Council published very authoritative studies of the central role of chemical research for both science and society in 1965, under the direction of Harvard University's Frank Westheimer, and in 1985, under the direction of George C. Pimentel of the University of California, Berkeley. A lay version of the later report was widely distributed.

ACS also has been very active. It published major reports on the role of chemistry in the environment in 1969, in the economy in 1973, and in medicine in 1977. Numerous other activities include National Chemistry Week. Started in 1987 as National Chemistry Day, it is an ongoing annual event involving all ACS local sections. The society also has developed many innovative and effective programs and products to aid in teaching chemistry and science at the elementary school through high school levels.

Another ACS initiative has been a permanent exhibit in the Smithsonian Institution in Washington, D.C., which opened at the National Museum of American History in April 1994. Entitled "Science in American Life," it has proven a disappointment to ACS. The society financed it but later disavowed it. Smithsonian personnel had total control of its content, as they do with all Smithsonian exhibitions. In ACS's view, the exhibit projects an unbalanced and inappropriate portrait of science. The Smithsonian claims that those who pass through the exhibit like it and leave with the same positive attitude toward science they had when they entered.

Other studies indicate the public has a reasonably positive view of scientists and realizes that science and technology are, in general, a good thing. This raises the possibility that what scientists interpret as antiscience sentiment also reflects public concern that it is used right.

Some observers are also thinking that, as essential as educating the public about chemistry is and will always be, the chemical community needs to be more than an instructor. As Roald Hoffmann outlined in

Smithsonian Institution's "Science in American Life" exhibit, funded by ACS, does not always portray science as beneficial.

1994

1997

Photo by David Hanson

Senators Phil Gramm (R-Texas, left) and Joseph I. Liebermann (D-Conn., center) sponsor bill, triggered by ACS-led initiative, to double federal R&D investment within 10 years. Also pictured are then-ACS Immediate Past-President Ronald Breslow (background, right) and Sen. Pete V. Domenici (R-N.M., right).

Honolulu in 1989, what it also needs to do is to show compassion.

As the Cornell University chemist, who is also a poet, put it: "Friends, if someone comes before you verbalizing anxiety over a chemical in the environment, don't harden your hearts and assume a scientific, analytical stance. Open your hearts; think of one of your children waking at night from a nightmare of being run over by a locomotive. Would you tell her 'Don't worry, the risk of being shot by a crack addict is greater?' "

In commenting on the public furor in 1989 over Alar, a growth regulant then used on apples and since banned from use on food, Hoffmann pointed out that many chemists responded by tut-tutting the concerns raised, impugning the motives of the public interest group that raised the issue, and pointing to it as a typical, irrational example of chemophobia.

Hoffmann added that, when the issue came up, he did not know what Alar was or that it was used on apples. In his view, the Alar controversy was "humbling, educational, and instructive; an opportunity to learn rather than to blow off some steam against environmentalists."

There are some signs that a shift from the tut-tutting to a more compassionate approach could be under way. They are clearest in the chemical industry—and especially since the 1984 chemical disaster in Bhopal, India, when leakage of methyl isocyanate from a Union Carbide pesticides plant killed thousands of people.

This accident left chemical makers with a very tangible problem that clearly could not be handled just with public relations and public education programs. It was also obvious that the "deny, dismiss, and discredit" response would be inappropriate.

The industry responded first with an immediate review of all of its operations and the installation of appropriate improvements. The second step was establishment of an industrywide program of health, safety, and environmental standards. Started in Canada and known as the Responsible Care program, it first went into effect in the U.S. in 1988. All CMA member companies, which collectively account for more than 90% of U.S. chemical production, are committed. The program has since been adopted by many overseas chemical industries as well.

One key element of the program is real, continuous, and extensive dialogue between chemical makers and their many audiences—employees, stockholders, over-the-fence communities and organizations including fire and rescue departments, regulators, environmental and public interest activists, the press, and the public at large.

As C&EN wrote in 1995, the underlying motivation for Responsible Care was to "transform public perception of this diverse and competitively successful industry from that of an arrogant culture pursuing profits at any cost to one that could be trusted to protect public and worker health and the environment."

It is turning out to be a long process. Chemical makers have upgraded their operations—they know a Bhopal-like incident in the U.S. is unthinkable. They are certainly having more extensive dialogue. But CMA's own studies show that a greatly improved public image for the chemical industry is still in the future. Things are no longer getting worse, but there aren't any clear signs they are yet getting much better.

Despite some incipient wavering when public concerns about chlorine and chlorinated hydrocarbons in the environment first crystallized in 1993, chemical makers are sticking with Responsible Care. They see it as their right and only path, regardless of how long it takes.

Maybe it is time for other elements of the chemical enterprise to examine the chemical industry's shift toward a little more humility, to more fully analyze the public's attitude toward chemistry and science, and to ponder Hoffmann's admonition about compassion.

It is possible that the chemical community will make more progress toward the public respect it has so long craved once it starts to show more respect of the public. Respect flows more freely when the street is two-way.

Over the past 75 years, chemical professionals have worked highly productively to push back the frontiers of scientific understanding and to exploit the resulting new knowledge to benefit society enormously.

This, of course, is what they are paid for and expected to do. But they can argue that they have a particularly brilliant record of social contributions. They do. The cost-benefit ratio for chemistry has always been enormously positive. It will continue to be so in the future and should give the chemical profession great confidence in working toward a less ambiguous relationship with the public in an ever-changing world.◀

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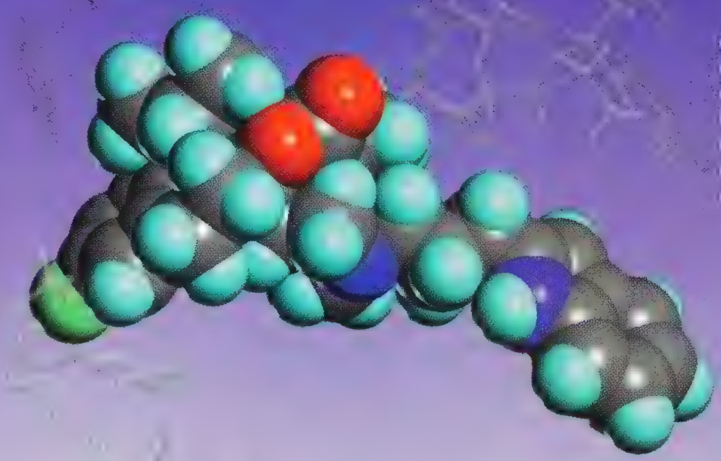

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Chemistry's Golden Age

While continuing to nurture the core of their discipline, chemists in the next 25 years will unlock many secrets of biology, create materials with almost magical properties

Rudy M. Baum
C&EN Washington

What will chemistry look like in 2023, the 100th anniversary of Chemical & Engineering News? *What research will dominate the pages of the* Journal of the American Chemical Society? *Will there be paper pages of* JACS, *or will the contents of* JACS *and other journals be disseminated exclusively by electronic means? Where will the best chemistry research be carried out—in traditional chemistry departments of universities or in departments of structural biology and materials science? Who will support the research? Will most universities still have chemistry departments?*

In an effort to answer these and other questions, C&EN assembled a panel of distinguished chemists to discuss the evolution of chemistry over the next 25 years. Columbia University chemistry professor Ronald Breslow moderated the discussion. Also participating were John D. Baldeschwieler, chemistry professor, California Institute of Technology; Allen J. Bard, chemistry professor, University of Texas, Austin; Jacqueline K. Barton, chemistry professor, Caltech; Theodore L. Brown, chemistry professor (emeritus), University of Illinois, Urbana-Champaign; Barbara Imperiali, chemistry professor, Caltech; Robert S. Langer, chemical engineering professor, Massachusetts Institute of Technology; Koji Nakanishi, chemistry professor, Columbia University; Daniel G. Nocera, chemistry professor, MIT; Douglas Raber, director, Board on Chemical Sciences & Technology, National Research Council, Washington, D.C.; Stuart A. Rice, chemistry professor, University of Chicago; and Richard E. Smalley, chemistry and physics professor, Rice University, Houston. In interviews with C&EN Managing Editor Rudy M. Baum, Richard N. Zare, chairman of the National Science Board and chemistry professor, Stanford University, and Stephen J. Lippard, chairman of the MIT chemistry department, also contributed their thoughts about the future of chemistry.

Seventy-five years ago, a new age was dawning in chemistry, an age when new techniques and new instrumentation would open a window on molecular structure and quantum mechanics would provide a truer view of the behavior of atoms. That window never closed, and molecular structure and quantum mechanics became the organizing principles of chemistry. The focus on structure was, in many ways, what set chemistry apart from other sciences—chemists insisted on an intimacy with the objects of their science unmatched by other disciplines.

Chemistry has fulfilled its extraordinary potential. It is, in fact, the "central, useful, and creative" science that Ronald Breslow called it in the title of his 1996 book on chemistry for nonscientists. So successful has chemistry been that its approach, its focus on structure and reactivity, now productively dominates other scientific disciplines. Is not molecular biology, in reality, chemical biology? Is not materials science, in fact, materials chemistry?

But this very success has given rise to doubts about the future health of the science of chemistry. Are the hottest areas of chemical research being appropriated by disciplines not identified as chemistry?

Photos by Peter Cutts

The group assembled by C&EN to discuss the future of chemistry seemed relatively sanguine about the future of the discipline. "We speak of chemistry as if we all know what it is," observed Breslow. "But there are fields of materials science (now departments of materials science) or fields of environmental science (now departments of environmental sciences), departments of biochemistry and molecular biology—all areas in which a large component is chemistry. Are chemistry departments going to encompass all this?"

Jacqueline Barton provided one answer to Breslow's question. "I predict there will be fewer chemistry departments, but not fewer chemists," she said. "Some universities won't have a chemistry department, but there will be chemists in departments of


Douglas Raber

life processes, new materials, neurological investigations. I think we should embrace this, because if you believe chemistry is a central science, which I do, then in fact we're all doing chemistry in these different areas."

Some panel members took issue with Barton's prediction of fewer chemistry departments, arguing that the discipline is simply too fundamental for a university to abandon the department altogether. Stuart Rice, for example, said, "Somewhere the intellectual core of chemistry has to be taught, advanced, maintained." And Robert Langer, the sole chemical engineer on the panel, noted, "Some universities have gotten rid of departments, sure. But chemistry? If they're going to get to the point where they're going to get rid of chemistry, that just seems to me like a very long way to go."

Douglas Raber, whose board at NRC spans both chemistry and chemical engineering, pointed out that there already has been a strong effort in many parts of the community—including funding agencies—to exploit the interdisciplinary nature of the chemical sciences, and that the real strength of the field lies at its interfaces with other disciplines.

While all panel members agreed that chemistry's push into related disciplines is irreversible, they also expressed a sense that chemists, even those working somewhere other than in a place explicitly called a chemical laboratory, retained a unique identity. Daniel Nocera, for example, observed, "Whenever I come up against this question, I always ask: How do you define a chemist? What makes a chemist unique? And then the question is: Will that ever go away? Chemists make new things and we study reactions. That's the core of this profession. And that can never go away. People will always rely on us for that."

"The fantastic thing about chemists," said Barbara Imperiali, "is that we all speak the same language. We share the same fundamental science. And therefore we can talk to each other about what we are doing. We have to ensure that the next generations can keep on doing that, that they don't slide away from us and become specialists in a field where they can't talk with a physical chemist, for example."

On a very practical level, Allen Bard noted: "I think as long as chemists keep getting jobs, there will be chemistry departments, especially at the graduate level. There are places that have eliminated, for example, physics departments. But as long as we can turn out students who can find employment, we'll be okay."

The comprehensive sequencing of the human genome and the genomes of various pathogens is going to have a profound effect on the future. The impact for intervention, for therapy, for dealing with resistant microorganisms—the potential is enormous. And that will transform the way we look at the practice of medicine.

John Baldeschwieler

So chemists will still be practicing chemistry in 25 years. They will be doing it in traditional chemistry departments, but they will be doing it in a lot of other places, too. But what research will they be carrying out? And what will they have accomplished between now and then? A lot of the activity, according to our panel, will be at those interfaces with biology and with materials science. Although some members of the panel believed that government and foundation funding patterns had distorted research priorities toward biological questions, the majority believed that chemistry applied to biology is one of the most intellectually stimulating of today's research frontiers.

"One of the greatest challenges of the next century will be for chemists to make life," Richard Zare said in an interview after the panel met. "A system that is self-replicating, self-organizing, and even has the possibility of evolving into other things—I think this is possible."

Creating life is, perhaps, the ultimate expression of chemistry turning toward biology, but it is not the only daring prediction Zare was willing to make. "We're going to move more toward bionic man," he predicted, "toward the possibility of putting man and machine together, at least for medical purposes, and being able to understand how to make implants of materials which will aid our health or which will monitor our health and tell us ahead of time, like on a car, when you should take it in to the service station rather than waiting for it to blow up on the freeway. I think there's going to be much more done with sensors and the connections of people with them."

Panel members, while no less excited about the prospects of chemistry applied to biological questions, were somewhat more circumspect than Zare in their predictions. But Zare wasn't entirely alone in his sense that chemists are on the verge of creating life, as this exchange between Nocera and Breslow indicates:

Nocera: And I imagine that in the next


Daniel G. Nocera

Jacqueline K. Barton

25 years, chemists will literally build membranes. And I'll bet you they will be able to pump protons across a membrane.

Breslow: We'll get functioning membranes. Will we turn them into cells?

Nocera: It will be the next step.

Breslow: Will they be alive? Will they take in nutrients and do some functions one can take seriously?

Nocera: Yes.

Raber noted that chemists already are making remarkable progress toward the improvement of life, if not actually creating it. For example, Koji Nakanishi pointed to alternative medicine as a source of new compounds for organic and medicinal chemists. But not just biologically active single compounds. Herbs and other plants used in alternative medicine contain complex mixtures of compounds, Nakanishi observed, and drugs based on traditional remedies will increasingly incorporate many of the compounds present in such sources. "It's not going to be easy to find out what is going on," Nakanishi said. "There are lots of synergies. We have to understand the biology, isolate the individual compounds, put them together as they were isolated from nature." That is, apply the powerful techniques of traditional chemistry to understand the total effect of an alternative medicine.

Imperiali echoed Nakanishi: "To bring this back to technology, we're in a position to screen synergistic mixtures like Koji described. The diagnostic tools are all becoming available. They were not available five to 10 years ago. That will bring alternative medicine into the realm of real-world medicine."

"Let's expand this beyond alternative medicine," Barton argued. "We've been thinking about gene therapy or protein therapies. I think, as you look to the future, it's going to go back more to small molecules, whether discovered through alternative medicine or rationally from the standpoint of using small molecules as regulators. In terms of signal transduction regulators, in terms of antiviral agents, it's not necessarily that we're going to go to bigger and bigger. As we figure out how these molecules interact with large molecules, we can use small molecules as the basis of a whole set of general tools—general solutions that we can use to fight different diseases."

MIT photo

Stephen J. Lippard

Another area where chemistry will have a significant impact in the coming 25 years is in neuroscience. John Baldeschwieler, for example, predicted that "in 25 years, we will understand neurochemistry well enough that we really will have some comprehension of brain function, the nature of memory—how, where, and what sort of systems format the memories that are stored. And we'll be able to intervene constructively in such matters as drug addiction, psychoses, appetite, rage, fear, stress, human intelligence, learning."

In an interview conducted after C&EN's panel met, Stephen Lippard said he plans to focus on neurochemistry during the sabbatical he is taking this year at the University of California, San Diego. "There are going to be very exciting, important discoveries in the neurosciences in the next 25 years, and chemistry will make major contributions to them," Lippard said. "We need to understand a great deal more about the molecular events that take place at the synapse. We know a lot about the conduction of current down nerves and the firing of muscles—much of it has to do with ion transport through channels and pumps—but many of the structural and molecular mechanistic

NSF photo

Richard N. Zare

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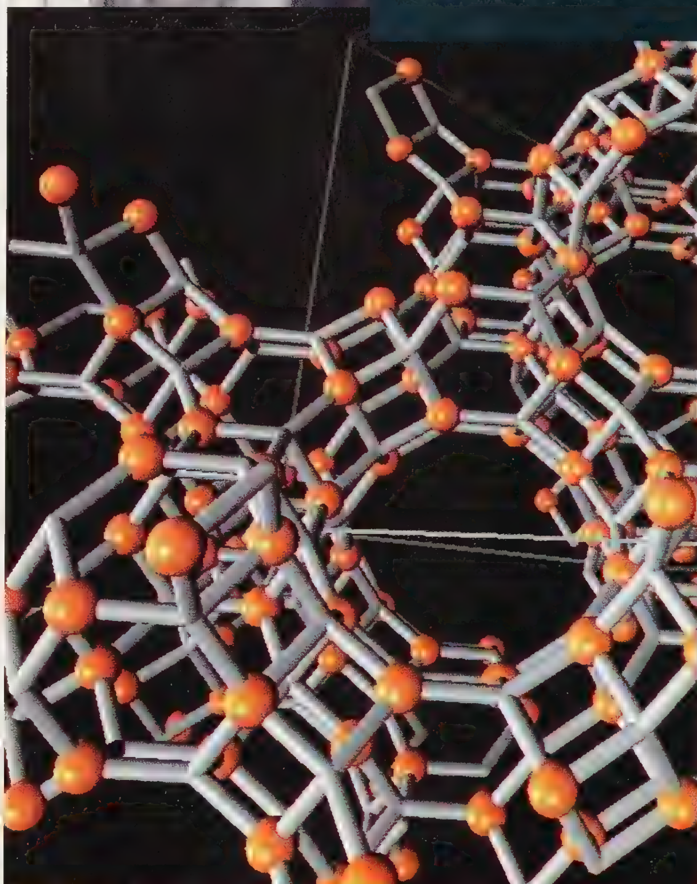



John D. Baldeschwieler

details of these processes remain to be uncovered."

Zare also focused on neurochemistry. "We are going to learn much more about the connection of chemistry and the mind," he predicted. One example Zare pointed to concerned sleep. "We don't understand sleep. We may discover that sleep actually is a vestige of a previous time that we don't need any more. Some sleep is needed, but not nearly as much as most people get. I am not so sanguine about extending the lifetime of people because of limitations on cell division, for example. But we may actually greatly change the nature of life if by taking the right combination of chemicals we only have to sleep an hour a night. There is so much to be learned about this, and ultimately it will involve chemistry. Ultimately the solutions will be chemical."

Artificial intelligence will be used to design syntheses, and, in fact, run them. We carry out synthesis in a 19th-century style—we have better glass, better analytical tools. But there hasn't been a real advance in the automation and computerization of synthesis. That's going to change.
Allen Bard

Panel members predicted significant advances in all areas of synthesis. Breslow, for example, pointed to work on synthesizing complex carbohydrates. "Focusing on carbohydrates is way overdue," he said. "Every cell surface is identified, essentially, with cell-surface antigens, which are all carbohydrates. And there's pretty good evidence that bacteria recognize cells and invade them, in part, by binding to complex carbohydrates. There's a lot of synthetic work going on to develop the methodology to make these materials. It's clear that this is going to lead to very important pharmaceutical applications."

And chemists will increasingly harness cells to carry out syntheses for them, Imperiali argued. "We're going to get a far better appreciation of how to use biological systems to create compounds on demand. We're really at the brink of that already with advances in genetic engineering."

Over the next quarter century, the fundamental understanding of chemical reactivity also will advance significantly, panelists predicted. "Within 25 years, most reaction mechanism studies of the kind that we do now on simple reactions will be replaced by computational studies," Breslow predicted. "Right now, a computer can generate a complete reaction profile and create a movie showing everything that happens during a reaction. The problem is, we don't know whether it is accurate. We will get to the point where computations will be good enough that every time we check the thing, it will turn out to be consistent with experiment, and we will finally conclude that we don't have to do the experiments any more."

Such a capability, Breslow added, will make it possible "to predict, for example, what kind of catalyst you would need to add to make a reaction go, and how that catalyst would operate. You should also be able to predict what reaction would occur between two materials that have not yet been put together—predict products and reaction rates that haven't occurred yet."

Advances in catalysis—moving toward rational design of catalysts—caught the attention of Theodore Brown. "In spite of all we know about catalysis, a lot remains Edisonian," he pointed out. "Catalysis research is pretty much a trial-and-error business. When we discover a new catalyst, we're delighted and we exploit it as much as we can. But we don't know where the next one is going to come from. The combination of combinatorial chemistry and computational methods may lead us to the point where we actually have a library of catalysts designed to do specific things. That has tremendous implications because it allows you to produce compounds more or less on demand."

Barton seconded Brown on the ability to "design a catalyst to tailor-make a material that we want." She also predicted that "manufacturing will be cleaner. We will be doing oxidation chemistry with oxygen rather than with chlorine. And we will focus manufacturing on preserving the materials used and minimizing the energy required to carry out the necessary reactions."

Another area that several panel members focused on was increasing sophistication in analytical techniques. "I think there will be continued development of techniques to measure smaller and smaller quantities—single-molecule quantities—to the point where there will be a vast array of probes of all kinds for biomedical and industrial applications so that one can continuously monitor or test events of chemical importance," Rice said.


Koji Nakanishi


Stuart A. Rice

Added Richard Smalley: "One of my favorite dreams is developing true spectroscopies for individual molecules, spectroscopies that are really worthy of the name. Not just touching the top of the molecule or pulling a macroscopic electric current through it, but actually doing, for example, NMR on a single molecule."

Well before 25 years from now, carbon fibers and boron nitride fibers of molecular perfection, both in small random lengths and in continuous lengths in cables, will be produced in millions of tons per year.
Richard Smalley

Another area where chemistry will have a major impact in the next 25 years is materials science. "I think we are already seeing advances in materials science in the broad sense, ranging from metals to polymers," observed Rice. "And I think that manufacturing processes are going to take advantage of this, in the sense that we will be using more 'designer material' instead of bulk material. For instance, if you want a bridge to withstand certain stresses for a certain period of time, then you will be able to order up the materials you want to make the bridge out of. And the economies of manufacture will be sufficient to make that possible, and we will understand enough about designing materials to make that possible."

Research on the electronic properties of organic compounds will result in new electronic devices such as displays, memories, and field-effect transistors, according to Bard. "I think there will be an organic electronics industry growing out of this."

"I agree," Smalley responded. "In fact, I'll up you two or three orders of magnitude. I now am beginning to believe that molecular electronics really is possible and will happen." Smalley, who shared the 1996 Nobel Prize in Chemistry for the discovery of the fullerenes, based his prediction on work in his laboratory and others directed at synthesizing and characterizing carbon nanotubes.

Certain nanotubes are truly metallic, Smalley said, which means "we have a way in organic chemistry to make metallic wires. And by hooking these things together with chemical perfection, we ought to be able to make the equivalent of essentially every circuit element that we can make in the macroscopic world out of molecules. If that's true, it may well end up that, well before 25 years from now, there is a very robust side of organic chemistry where the practitioners, instead of making pharmaceuticals or polymers, will be making electronic devices."


Richard E. Smalley

Smalley also foresees numerous other applications of carbon nanotubes and their boron-nitrogen analogs. He calls one of them "paint by numbers."

"I imagine that a single buckytube is the stick of a paintbrush," Smalley said. "The bristles are catalyst molecules bound to the tip of this nanotube stick." The "paint" in Smalley's metaphor is composed of reactant molecules drifting by in solution. The canvas is some surface "on which we want to build structures of molecular precision. Paint adheres to the canvas whenever the surface, the catalyst, and the reactant molecules come together at the same time. Depending on the 'number' for the region to be painted, the reactant molecule and the catalyst on the end of the nanotube stick are changed.

"This gives you at least one way, in principle, to build something as complex as a Pentium chip with molecular precision," Smalley suggested. "The more we think about these things, the less ridiculous they seem."

Langer pointed to an intersection between advances in materials and biomedical research. "Biomaterials will advance due to basic research that is now being done on dendrimers, electrically conducting polymers, polymers that can undergo phase transitions, and many others," he said. "These will be applied to new drug-delivery systems, and to creation of new tissues such as skin, cartilage, or even nerves."

It will become increasingly clear that it is a crime against the future to take petroleum and burn it. Not just because of global warming, but because we are burning away materials that are tremendously valuable for other uses.
Ronald Breslow

Chemistry is a practical science, and C&EN's panel predicted that the next 25 years would see contributions from chemistry toward addressing a variety of societal problems. "It seems to me that the prob-


Robert S. Langer

lems in 25 years for mankind are going to involve energy and food," Bard said. "I think world population is bound to keep increasing, and both food and energy will be issues. We need portable fuels. If we stop burning oil—and even if we don't, we're going to run out of it—we need to harness chemistry to make different liquid fuels. A hydrogen economy sounds good, but unless we develop good ways of storing hydrogen very densely and safely, there will still be a lot of liquid fuel needed."

As to food, "chemistry is starting to make food," Bard said. "We make artificial fats that are not fats. I have a feeling that trend will continue, that we will make food of different types."

"Twenty-five years from now the internal combustion engine will be found in museums, battery technology will finally have solved the problem of how we transport electrical power, and fuel cells will be practical devices, not just interesting things to talk about in freshman chemistry courses—cheap enough and powerful enough to be used routinely," Smalley predicted. "We may have solved the problem of cheap solar energy, cheap enough so that you would be a fool to build a power plant any other way."

"One of the biggest failures of chemistry in the 20th century has been the inability to develop good fuel-cell catalysts," Lippard said. "I think the electric car is the invention which chemistry can make a reality. Electric cars would dramatically restore the beautiful cities of the world to their previous pristine glory. Imagine what Mexico City, Florence, Rome, and Paris would be like without automobile pollution. That's really important, fundamental research—new batteries, new fuel-cell catalysts that would push that technology forward."

By contrast, Rice predicted that concerns about global warming will have led in 25 years to a revitalization of the nuclear power industry. "Without understanding the mechanism of global warming, one can get confidence that the consequence of apparently small changes in temperature can have dramatic changes on humankind," Rice said. "If that is accepted, then the consequences of ignoring it, I think, will become so apparent that people will be willing to say, 'We don't know whether fossil fuel burning is the primary or only source of global warming. But there are alternatives, and we ought to at least ensure that the alternatives are available to us and start using some of them.' "

These experiments in electronic publishing, many of them may be failures. But with the power of this methodology and the capacity to reach larger numbers of people more quickly than ever before, it's inevitable that people will find legitimate ways to use them to publish their scientific results. And they're going to usurp the traditional methods.

Theodore Brown

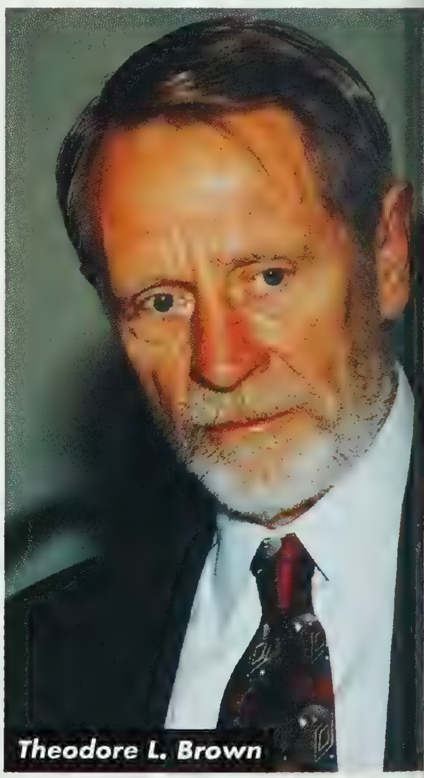
Communicating the results of research is the hallmark of all science. Members of C&EN's panel were unanimous in predicting that current trends in electronic publishing will profoundly change how chemists communicate.

"When a new discovery is made, will it be possible for someone to post the discovery on the Internet, obviating the normal means of publishing through peer review?" Brown asked. "In the high-energy physics community, which is a small, self-contained community, there is already a new process. Los Alamos National Laboratory runs an electronic publishing operation that allows people to post their papers on the server. Others read them, comment on them, communicate about them. Eventually, they get printed, but they're old hat by then.

"Chemistry hasn't adopted that practice yet, although there are electronic conferences going on. I have a feeling that, as these technologies become more and more thoroughly embedded in our day-to-day practices, they are going to affect the ways in which we communicate with one another and the ways in which we disseminate our results."

Bard, who is the editor of *JACS*, responded to Brown: "My feeling is that the high-energy physics community can get away with that because they are a tiny community, and there's very little practical import to what they do. I don't think it is going to be popular among chemists. My own feeling is that the signal-to-noise ratio in these electronic publications is really bad. It may be readily available, but you spend a lot of time gleaning out what's worth looking at from a lot of junk. So I guess I'm old-fashioned. But I have a feeling that traditional modes of publishing are going to be with us for a long time."

To which Brown replied: "I'm not arguing that we already have a process that is a good substitute for what we've done traditionally. What I am arguing is that


Theodore L. Brown


Barbara Imperiali

there are new forms of communication out there. And it just doesn't make sense for us to expect that in 25 years we are going to be still doing journal publishing the same way we do it today."

Imperiali weighed in with a defense of traditional publishing and a plug for the Internet. "The volume of material on the Internet is getting out of control. And the quality control has to go down because of the volume. I have to echo Al. I feel very old-fashioned about this. I think we have to maintain a certain level of things that we know we can trust the quality."

That said, Imperiali continued, "I think the Internet is an outstanding medium for collaborative work between colleagues. In addition to increasing access to information, it takes away the fact that we are in different cities and allows us to communicate and make things happen."

Smalley's vision encompassed the immediacy of electronic journals with the quality control of peer review. "In 25 years, we will be getting our journals transmitted directly to a little thing that will feel like a book. If we want, it could smell like a book. But it will be every book that has ever been written. However, it will still be true that the best researchers will want their work to be published in the most exclusive environments.

"Almost like advertising, you pay for readership. You want people to read it. That's one of our responsibilities in science. It doesn't matter if you discovered it; you've got to affect the corporate knowledge. And so I know in my own group, and I assume in most groups, we try to wait so we can really put a blockbuster out there, rather than dribbling it out in journals that won't get read. But I can't imagine waiting for a piece of paper to arrive in Texas before I read it 25 years from now."

At the beginning of the forum, the panel was instructed to take an optimistic view of research support over the next 25 years. But sources of support for basic research, the types of research that are being supported, and the relationship between industry and academe are subjects of interest and real concern for these academic chemists. One message that came through loud and clear was that it is imperative for the government to continue strong support for basic research.

"I think there's a true concern for people who are entering academia right now, that they are stuck between a rock and a hard place, deciding whether to follow application-driven science or curiosity-driven science," Imperiali said. "The funding opportunities are becoming so limited. I think we should be very concerned about moving away from truly fundamental science just because of funding decisions."

Barton suggested that industry is likely to support some basic research at universities out of self-interest. "The relationships are changing between industry and universities, and they are going to continue to change," she said. "Industry isn't interested, by and large, in having universities do their research. They want universities to do the more fundamental research, and then let industry run with it."

In terms of protecting basic research, perhaps Bard said it best: "I think my gravest concern is how to protect basic research. If I have to make a prediction about the future, I would predict that five of the most important things that will be developed in the next 25 years have not been discussed at this table. And they will be the result of fundamental research that some young scientists being supported by the federal government are going to come up with."

With adequate funding, the next 25 years look at least as bright as the past 75 for chemistry. Indeed, the chemists assembled by C&EN to project the future were almost irrepressible in their enthusiasm for what chemistry can accomplish. "What is most important about chemistry is that we make new things," said Lippard. "We don't just study the natural world, we make new molecules, new catalysts, new compounds of uncommon reactivity. Part of our subject allows us to be creatively artistic through the synthesis of beautiful and symmetric molecules. Our ability to rearrange atoms in new ways allows us a tremendous opportunity for creation that other sciences don't have."

In fact, if they are right, the next 25 years may turn out to be a golden age for our science. They will be an age during which chemistry unlocks many of the secrets of biology, creates materials with almost magical properties, and contributes to the environmentally sound production of food and energy sufficient to feed the world's population and fuel its economic activities.◀


Allen J. Bard

Industry's Bright Outlook

Trends that have been developing over the past decade will continue and have far-reaching future implications for the structure of the industry, for trade, for research, and for who succeeds and who doesn't

William J. Storck
C&EN Northeast News Bureau

What does the future hold for the chemical industry? Will globalization erase the national character of the industry's major players? Will life sciences claim even more of the industry's hallowed names? Will the U.S. branch of the industry continue to make a large positive contribution to the nation's trade balance? Will the trend toward sustainability end the industry's battles with regulators and environmental activists?

To explore these and other related topics, C&EN invited a group of leaders from industry and government to participate in a panel discussion of the chemical industry over the next 25 years. ACS Immediate Past-President Paul S. Anderson, who is senior vice president for chemical and physical sciences at DuPont Merck Pharmaceutical Co., moderated the discussion. The panel also consisted of E. Gary Cook, chairman, president, and chief executive officer of Witco Corp.; Earnest W. Deavenport Jr., chairman and CEO of Eastman Chemical; J. Michael Fitzpatrick, vice president and chief technology officer of Rohm and Haas; Judith G. Giordan, vice president and corporate director of research and development of International Flavors & Fragrances; J. Roger Hirl, president and CEO of Occidental Chemical; Martha A. Krebs, assistant secretary for energy research at the Department of Energy; and Brian W. Metcalf, senior vice president of SmithKline Beecham.

Restructuring has been the guiding principle of the chemical industry for more than 10 years. Employment cuts, acquisitions, divestitures, mergers, strategic alliances, changing company directions, expanding into new geographic areas and contracting from others, and focusing on core businesses have all been in the news and on the minds of corporate executives and employees alike. And this restructuring will continue. The evolution of the industry will be slow. It will be like watching the seasons change. Day-to-day, one doesn't see much difference, but suddenly it is summer—or winter—and the entire landscape looks different.

The result will be that the landscape of the chemical industry 25 years from now will probably look much different from what it is today. The changes will be at many levels. The trend that began in the mid-1980s of the industry splitting itself into two distinct camps—companies largely devoted to commodity chemicals and those involved primarily in making value-added chemical products—is expected to continue. In the first camp are Huntsman Corp. and spin-offs such as Lyondell Petrochemical, Geon, and Aristech. In the other camp are large- and medium-sized companies such as Monsanto, ICI, DuPont to some extent, Hercules, Arco Chemical, Witco, and Morton International. And the two-camp trend likely will have a variety of subsets, such as companies that will tend toward or reinvent themselves along life sciences lines such as Monsanto and Hoechst today, biotechnology companies, custom manufacturers, and custom research laboratories.

Paul S. Anderson

Photos by Peter Cutts

These structural changes will impact the chemical industry in a number of ways, including plant locations, foreign trade, research and development, employment, and, to a certain degree, will determine which companies will survive and which will not.

Michael Fitzpatrick is one of the panelists who believes the two-camp trend very likely will continue. "I think what will drive that will be the financial markets themselves; they'll be asking for better recognition of shareholder value in the different parts of the portfolio of the business. I think that's driving it more than any strategic issue within a company itself. But I also think that as long as management struggles with the difficulty of managing a company that has a very different portfolio split in it, the commodity versus specialty, there will be some internal driving force for splitting it out to enhance the focus."

Roger Hirl agreed that the "asset shuffle" is going to continue. "I think the best example we've seen of that recently is certainly Unilever and ICI." ICI is selling off its basic chemicals businesses and has acquired Unilever's specialty businesses. Hirl asked, "Would anybody have thought two years ago or even a year ago that something like this was going to happen, where suddenly a company [ICI] says it's going to spend $8 billion to acquire assets and it's going to divest $3 billion or $4 billion of its existing portfolio?"

Earnest Deavenport took something of a contrarian view. Although he believes that in the short term of five to 10 years the shift will continue, he sees two reasons for it to eventually reverse itself. The first is that conglomerates tend to run in cycles in the U.S. and the world. And this may be the time in one of these cycles when focused companies are more in favor. "As you look at some of the Asian players who are coming into the scene," he said, "obviously they don't tend to think in terms of specialty and commodity. They just think of investing their resources and their capital dollars and building large chemical companies."

And the other factor, he said, is "public versus private. I think today you are seeing a lot of companies going private. If you are a private chemical company, it doesn't really matter if you're a commodity company, a specialty company, or a combination of both. I think Huntsman is probably a pretty good example of this."

All of the panelists agreed, however, that while there always will be commodity chemical companies, there will probably never be a true specialty chemicals company because specialties age into commodities over time.

Gary Cook reinforced this point: "If you are really going to have a specialty business, you are going to have to be feeding in from the top all the time because you'll be dealing off the bottom. What that really means in practice is that what we are calling specialty companies will always be diversified because you will always have products in different stages of their life cycles. Unless you have both the wisdom and the discipline to recognize instantaneously when your specialty creeps over into the pseudocommodity range and sell it at that second, you will always be running a diversified company."


Brian W. Metcalf

In the pharmaceutical industry, however, Brian Metcalf sees a different kind of restructuring. Here, many companies looking for core competencies have already divested themselves of their agricultural and other nonpharmaceutical businesses. However, Metcalf said, "There's another fracture happening in the pharmaceutical industry—whether one becomes a completely vertically integrated health care company, going from drug discovery through to patient management, or whether one stays strictly at drug discovery."


Earnest W. Deavenport Jr.

Examples of the two approaches, according to Metcalf, are Glaxo-Wellcome, which sticks with pharmaceuticals and drug discovery, and Merck, which is considering vertical integration through to patient health care management. "Companies are now rolling the dice which way they are going to go," he said, "and these will be long-term decisions that will be difficult to reverse. I'm not sure which is going to be best."

The other fundamental structural change in the chemical industry is globalization of the industry, not only in terms of companies, but also in the buildup of national chemical industries around the world—a trend that will continue well beyond 25 years from now.

The panelists agreed that in terms of markets of the next 25 years, the U.S.—because of the size of its gross domestic market—will remain the premier single country outlet for chemicals in the world. Thus, it will remain the chemical manufacturing center.

But what is already happening and will continue to happen is that manufacturing will become even more spread out than it is today as manufacturing follows the markets. This means that chemical manufacturing will spread to what are today the developing countries as their gross domestic product, standard of living, and disposable income all improve.

This does not mean that production capacity is going to expand in these regions at the expense of more developed countries, especially the U.S., the panel agreed. By and large, few plants will be shut down to be replaced by operations in developing countries. It does mean, however, that chemical producers in developed countries are going to have to make a choice on an individual plant or product basis—invest in plants in the future in the home countries or invest abroad. Home country investment will be primarily dedicated to the domestic market or markets in easily accessible countries nearby.

A couple of important results will derive from this. Growth in chemical investment in developed countries will slow. There will be increased manufacturing parity among all of the regions of the world. And there will be increased competition among companies around the world—especially between those companies headquartered in the developed countries and native companies in developing nations.

Much of the foreign investment and export interest for U.S. and Western European countries over the past few years has been in the Asia-Pacific region. But, inspired by the success of economic reforms in Latin America, investment by companies headquartered in developed countries is beginning to grow in that region.

And there will be an increasing interest in Eastern Europe. Hirl pointed out that there is an enormous market in the former Soviet COMECON economic grouping of countries and other countries of the former Soviet Union. "That's a big export market that we tend not even to think of when we talk of exports into regions. Political stability is an issue. But, I think that in five or 10 years as Russia and all of those countries come to grips with free enterprise and all the things that affect free enterprise, the market will develop."

Cook believes that this market in what he says stretches from "Warsaw to Beijing" likely will be developed primarily by European companies. "If you talk about an export market, that's a pretty big one that sits right next door. And the European companies are doing a lot of investing there today to take advantage of primarily the raw materials base that, up to this point, they have been denied."

As Fitzpatrick pointed out, manufacturing efficiency of the new plants being built outside the U.S. will unquestionably be higher than the average for the U.S. "It was not by chance that Germany and Japan became the manufacturing powers that they were following World War II," he said. "Their manufacturing base was destroyed during the war and rebuilt with the most modern technology in the 1950s. That gave them a level of efficiency and productivity that the U.S. manufacturing base, which was not destroyed, did not have.

"Now we are seeing a new installation of capacity in the Far East and it's going in with modern technology."

One real consequence of the buildup of modern, efficient capacity in nontraditional places around the globe—plus the possibility of more favorable raw materials costs in Asia and the Middle East—will be the effect on exports. The U.S. historically has enjoyed a large chemical trade surplus—exports exceeding imports. In 1996, the surplus totaled almost $18 billion, and was projected to be almost $20 billion for 1997. But over the next 25 years, that surplus likely will drop, if not actually disappear, as manufacturing abroad replaces exports from the U.S.

Deavenport believes that the U.S. will go from a nation that exports products to one that exports technology. Although not sanguine about the trade surplus, he said that the way it can be made to last longer is for the U.S. to "really promote free and open trade around the world." Commodity chemicals, he said, will cease to be traded on a large scale fairly soon because a U.S. company cannot afford to ship a 30-cent-per-lb product to Asia. "If you're selling a $2.50- or $3.00-per-lb product, shipping costs are not very significant," Deavenport said. "But duties can be very significant."

The other factor that is spurring exports now and probably will for the immediate future is trade blocs. Deavenport pointed out that, since the passage of the North American Free Trade Agreement, Eastman Chemical's business in Latin America has increased 30%.

Even though trade blocs are important and will continue to grow, it would be better if they expanded in size, becoming more efficient rather than increasing in number. The danger in this, many panelists agreed, is that they could become very powerful, regional blocs that could hinder global trade.

However, these trade blocs are probably only a transition to freer world trade. If the World Trade Organization works as it is supposed to, eliminating tariffs and nontariff barriers to trade, the need for trade blocs will be negated within the next 20 or so years.

Research

It is not only trade that will change as the chemical industry restructures along product lines and as it becomes more global. Research and development is in for some big shifts, too. Like the industry, it will restructure vis-à-vis commodities and specialties, and it, too, will become global. In both cases, the question of "big R/little d" and "little r/big D" will come into play.

Thus, the preponderance of R&D at the commodity companies will be big D process development, continuing to drive down the cost of production. This includes changes in plant processes and R&D in new catalysts.

Specialty-oriented companies will, conversely, see more big R research—inventing and developing new value-added, proprietary products.

But companies will be increasing their R&D initiatives in regions where they will be investing. Many European companies have been at the forefront of this movement with R&D investments in the U.S. Increasingly, companies will be doing research, and especially development, in places such as Asia, Eastern Europe, and, ultimately, Latin America.


E. Gary Cook

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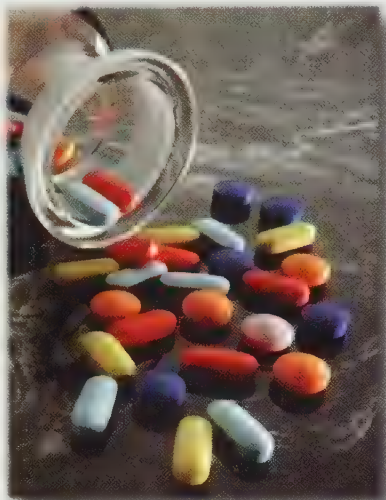

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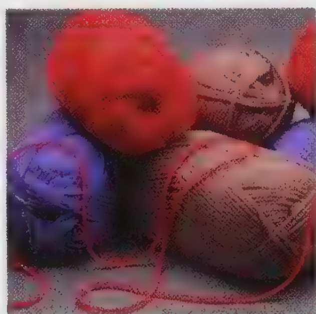


CIRCLE 99 ON READER SERVICE CARD

Deavenport believes that 25 years out the research centers will continue to be in Europe and the U.S. In 50 years, one might add Asia to that, and in 100 years, Latin America.

He noted that the key strength the U.S. has is its research universities, and as long as the country maintains that strength and other countries don't catch up, the U.S. will maintain a leadership position, certainly for the next 25 years.

Metcalf, however, said the spreading of research around the world is already happening, and that some of the technologies the U.S. needs—particularly in the computer age—are already easily accessed in places such as Singapore. Parts of the drug industry, he said, are using Singapore for clinical trial assembly, for data manipulation, and for bioinformatics.

Judith Giordan added that in some areas of the world, where there is a demand for technology but perhaps little infrastructure, countries will simply leapfrog to get where they want to be.

But Hirl pointed out that the infrastructure is also necessary. "Because prizes, such as the Nobel Prizes, are given to individuals, the tendency is to look at this as an individual enterprise. This is absolutely not true. It requires massive infrastructure and collaborative efforts and resources around that technology, that invention, and the individual who is cited as having invented it. This does not exist in many of these places, and it takes a long time to develop it."

There are other barriers to many countries becoming centers of research. Deavenport said that in some countries the educational system must be changed—not only at the university level, but kindergarten on up. "I think you are talking about three generations, minimum."

Cook added that not only the educational system needs changing, but also the political system. "I do not believe the level of innovation and creativity and inventiveness that comes out of a society as free and open as ours is coincidental nor that all the societies we're talking about have significantly more restrictions on entrepreneurial or independent activity than we have in the U.S."

Judith G. Giordan

Although the U.S. and Europe have and will continue to have the lead in research because of their university systems, that doesn't mean that there are not pockets of excellence elsewhere. China, for instance, is developing these pockets. Fitzpatrick pointed out that Shanghai Institute of Organic Chemistry is doing world-class small-molecule synthesis, and that Beijing University has some very good departments. "We're already seeing some interesting technologies, particularly in rare-earth chemistry, coming from Beijing University," he said.

Martha A. Krebs

"I think it may take three generations [to develop the critical mass]," Fitzpatrick continued, "but they're going to be a formidable contributor to technology in the future."

According to Giordan, the three-generation framework may be too long; it may take less than that. "In some of those specific research areas in their pockets of expertise," she said, "if they see it in their national interest to invest, if they put it together, there could be a critical mass in certain areas far more quickly than one imagines."

There was consensus among the panelists that there is little to worry about in terms of getting the researchers for the future. All agreed that the researchers being turned out by U.S. universities are highly trained, very insightful scientists.

However, there was a worry throughout the panel that the academic model may not be especially good for corporate research and must be overcome in newly recruited chemists. This model teaches a researcher to be more of a lone wolf and competitive with ideas, which is not the way research is done in industry, where more of a team approach is followed. To counter this, many companies are looking for ways to strengthen the interface between industry and academia.

Martha Krebs worries whether there is a disconnect between the culture of a company and the culture of R&D. "In particular, the disconnect becomes strongly apparent when there is a downsizing or a major change in investment in R&D."

Both Krebs and Giordan said that there must be more done in universities, especially with cross-disciplinary courses combining science and business. But, Giordan said, "while this is important, both chemistry departments and business schools look on this with skepticism."

Environment

One of the great problems that the chemical industry has faced for years is its environmental record and the perception of that record. Paul Anderson noted that the enormous advances in analytical methodology have made it possible to detect the presence of smaller and smaller impurities, and questioned the impact this has had on the industry.

Krebs said: "Having watched a number of issues develop, the smaller the concentrations you can detect, the less tolerant publics are for having those kinds of nominal contaminations. So the relationship between the regulator and the regulated depends not just on advances in science, but also on how we explain what the information means."

Thus, according to Krebs, the burden that it places on both scientists and the industrial community is an even greater burden of explanation and responsibility for public understanding. "Otherwise, the character of regulation, the relationship between the parties, is not going to change unless we do more with respect to public understanding."

The panel agreed that the regulatory process is as much and possibly more a political process than a scientific one. Therefore, the issue for the future of regulation will be the political and economic environment and how well those in political power, those able to pass laws, understand the technical issues involved in regulation.

It also agreed that the "command-and-control" aspect of regulation should change toward a cooperative effort between the regulator and the regulated. Hirl was outspoken on this: "If everybody continues to perceive a command-and-control type of regulatory process, then both sides—environmentalists and industry—tend to look at that and say, 'If I can come up with something that will cause the regulator to exercise command and control, then I'm going to work that issue.' "

However, Hirl said, "If everybody looks at things in a cooperative cost-benefit analysis, not only in legislation, but also in regulations that follow, then I think the whole perception of the technology that will find lower and lower parts per trillion in substances will be easier to deal with. If we work in an environment where the precautionary principle is the methodology by which our adversaries suggest regulation, then we are going to question the technology and the analyses and so forth. If we live in a more cooperative environment, then it's better."

There was a consensus among panelists that regulation should change, but no consensus that it would. Deavenport was perhaps the most pessimistic. He noted that in Europe there are very strict regulations, but that the parties have the ability to sit down and deal with the facts in a way much superior to what exists in the U.S.

"As long as we [in the U.S.] have command and control, the activist groups really don't want to pay attention to science. These groups tend to benefit from conflict. Harmony is not their game. So I think that somehow government and the free-enterprise system must move to more cooperation and try to deactivate this conflict that always tries to arise. Otherwise, we're not going to get anywhere in the next 25 or even the next 50 years.

"So I think that we have to change this environment where conflict gets the regulators' attention. Somehow the Europeans have figured out a way to do that much better than we have."

Future technology

All of the panelists made a stab at crystal ball gazing into the technological future, at least for the next 25 years. They generally foresee a chemical enterprise that is optimistically more at peace with nature and serving mankind in a gentler, nobler manner. Their predictions ranged from changes in food production and pharmaceuticals to catalysts and pollution-free industry.


J. Roger Hirl

Anderson: I have two ideas that actually come from a friend who is very interested in sustainability. Food plants will be cultivated in what is now desert by use of saltwater-tolerant plants from genomic engineering. That technology actually exists in rudimentary form today, so it's not so wild. The other prediction is that plants, because of this, will actually become the main source of oil and plastics. Again, the rudimentary technology for that already exists today.

Cook: One of the impacts that the interface between chemistry and biology will have will be on foodstuffs, not in terms of pesticides, fertilizers, and those sorts of things, but on things we actually eat. More and more chemistry is being used to generate synthetically—rather than in the ground—things we eat.

Another trend that already is taking place is "less is more." Agrochemicals was the first area to really demonstrate using less and less to accomplish more and more. The trend toward becoming more efficient both in our collection and use of fossil fuels and energy resources will accelerate in developed countries and begin to catch up in developing countries simply because there are higher value uses for them than burning them to keep us warm.

Deavenport: I think that what we will see in the next 25 years is commercialization of what's in the research laboratories today. What is in the research laboratories 25 years from now will be drastically different than what is there now. But, obviously, the biological processes will be much, much more commercial than they are today.

Also, information technology will dramatically change the way the industry interfaces with customers, suppliers, and our own employees around the world. You will see a chemical industry that looks entirely different in the way we source our raw materials, manufacture our products, and sell those products to people around the world.

Fitzpatrick: The first

place I would look for innovation is the interface between chemistry and biology, already in full bloom in biotechnology. But if you back it up into the chemical industry, what you will see is increasingly elegant catalysis that will model biological systems. If you consider the conditions under which we do chemical synthesis today compared with the very mild ambient temperature, aqueous conditions that go on in biological systems, we have a long way to go. There is also a specificity in biological systems that doesn't exist in chemical processes today. So I predict that there will be major advances in catalysis that will look more biological-like in their specificity and conditions under which reactions occur.

A second interface for innovation will be between chemistry and physics, which is only now beginning to blossom. And the products there will be electronics, optics, and materials.

Giordan: There is a profound change in healthcare trends that will affect the pharmaceutical industry. What we traditionally accept as Western medicine is not going to look like traditional Western medicine any longer. The whole nature of research will start evolving and much of people's desire to be responsible for their own wellness and to take proactive stances will require them to review what pharmaceuticals can do for them, and what individuals can do for themselves—for example, meditation and aromatherapy.

There should be, within organizations, true diversity, not in terms of gender or race, but using a holistic approach to solving a problem—going to where the skills are whether it be a scientist, a marketing person, or someone else.

And we should redefine our disciplines. We have already begun this, talking not about chemistry and physics, but interfaces. I would urge us to get rid of that and talk about technological imperatives of the future and how all of us can work toward these technological imperatives.

Hirl: In 25 years, the word pollution will have largely disappeared from our nation's vocabulary, as far as the chemical industry is concerned. There will be no pollution of the air, land, or water from the chemical industry. With the technological advances in processes and in environmental control and based on the chemical industry's commitment to Responsible Care and product stewardship, coupled with our outreach to the public, the chemical industry will be perceived and classified as a nonpolluting, sustainable industry. When pollution is debated in the public arena, the chemical industry will not be an issue.


J. Michael Fitzpatrick

Krebs: As a result of the Internet and connectivity that advanced networking technologies will make possible, we will be able to operate facilities at a distance. At the Department of Energy, we're already putting them on-line. It's not enough to give a real sense of presence, but we're close.

The other aspect of the advanced Internet will be the ability to move and process large databases. Using the Human Genome Project as an example, we are going to be able to see a totally different set of questions being asked about biological structures, about the connections between the structures and their functions, and, ultimately, about applications because of the combination of the availability of the databases and the instrumentation.

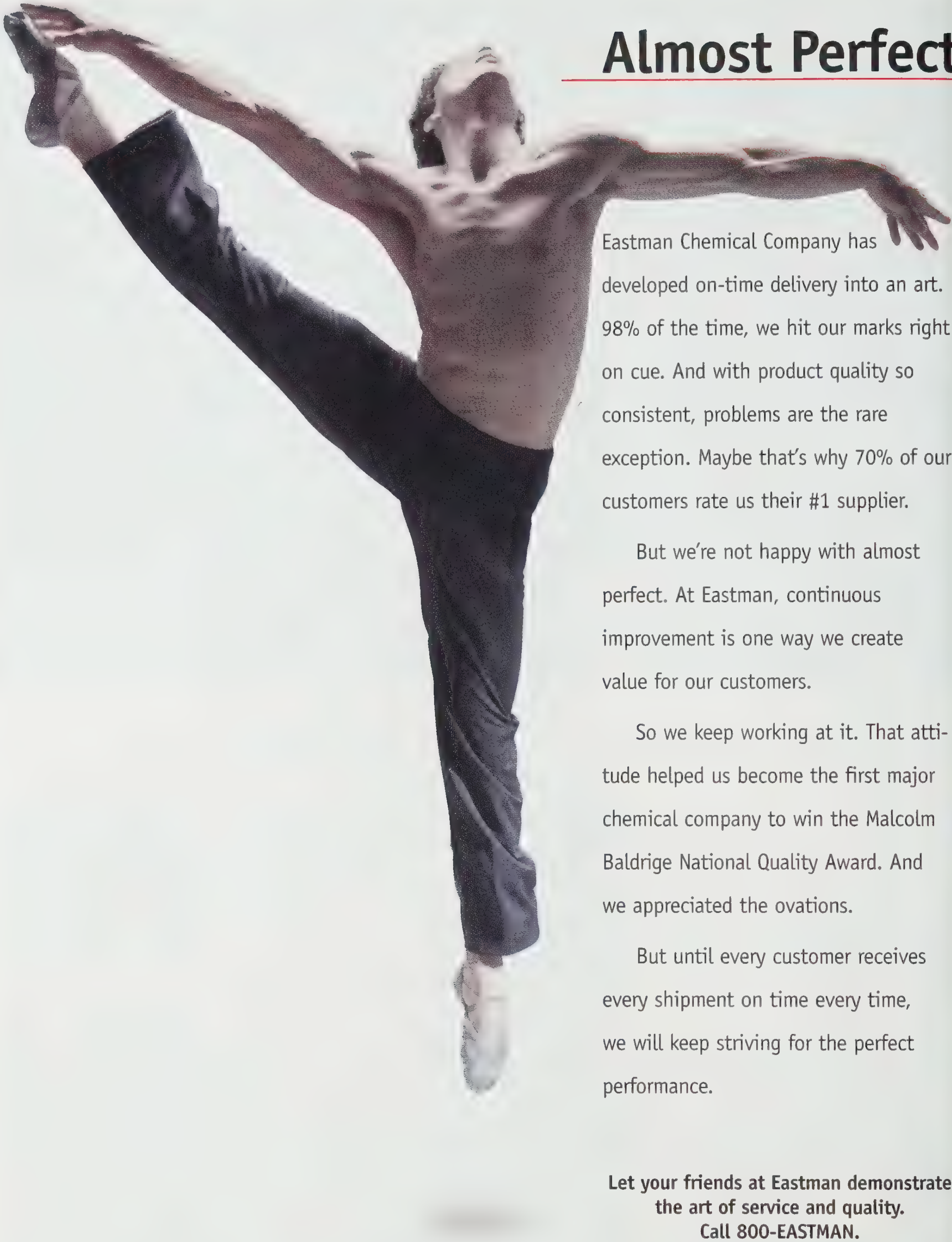
Metcalf: Discovery chemistry in the pharmaceutical industry is undergoing a revolution driven by the biological interface. Biotechnologists, who can sequence thousands of genes very fast, are sort of leaving chemistry behind. So discovery chemists in the pharmaceutical industry are now wrestling for the first time with automation, with making many compounds at once. Consequently, chemists have an image of being old-fashioned, not adapting to new technologies. But we are realizing this, and hence, there's a revolution.

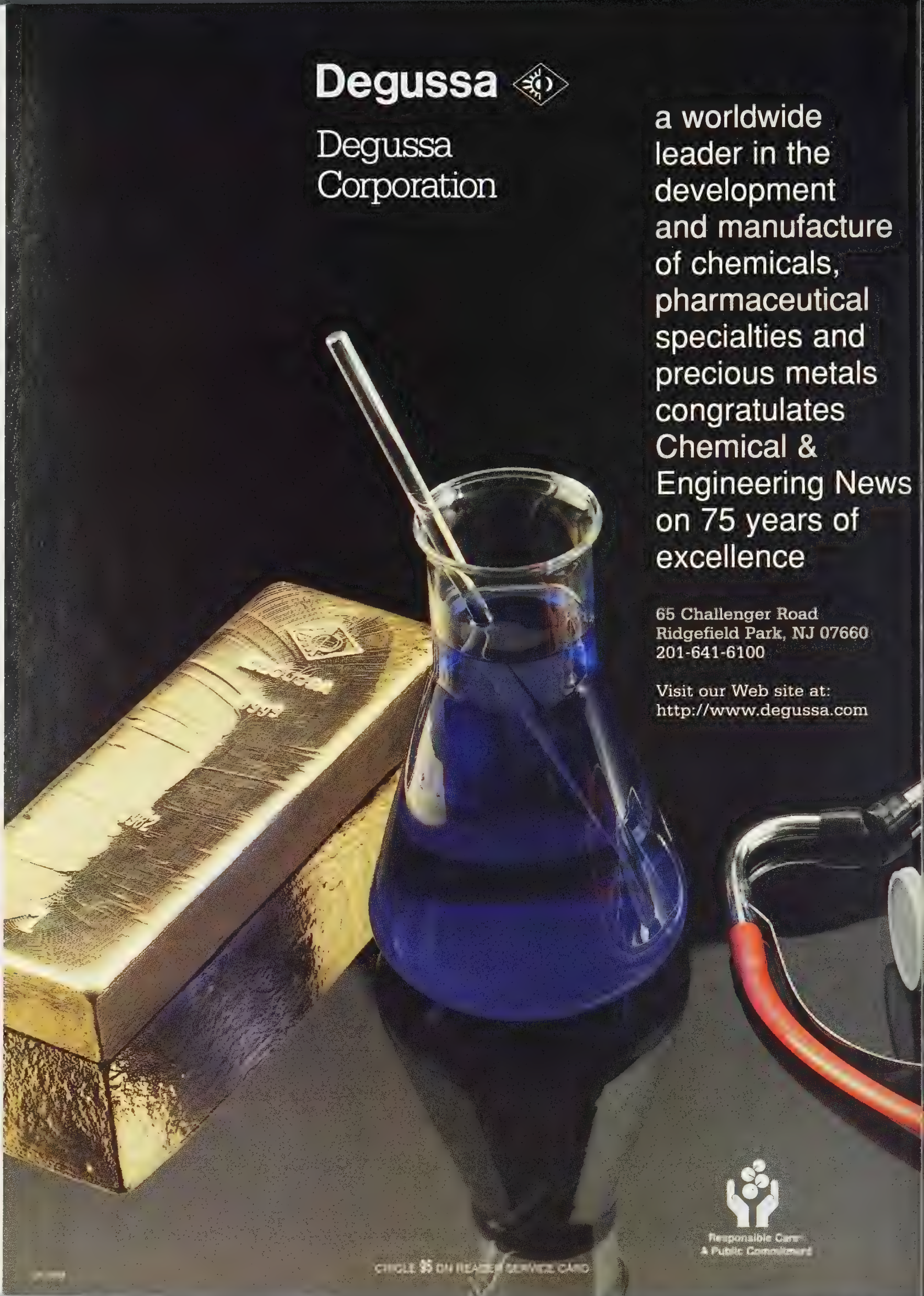
Paradoxically, the hundreds of thousands of compounds versus one at a time will create a shortage of chemists. There won't be enough chemists that we can recruit to take advantage of these discoveries.

I think that chemistry in the pharmaceutical industry also has been slow to move outside its field to bring in new technologies. We have to learn more from industries such as electronics, chips, and microetching.

Altogether, these distinguished panelists' views of the next quarter-century, when C&EN celebrates its 100th anniversary, paint a picture of a chemical industry that is far different from the one we know today. More than likely, many of the changes that will occur, many of the innovations that will change the character of chemical engineering and the industry it supports, have not even been thought about today.

So there will be many hills to climb in the chemical landscape and many precipices to avoid, but what should emerge is a continuing strong global chemical industry that will be an ever-increasing part of everyday life.◀

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Glenn Seaborg: A Towering Figure In Chemistry

Editors Note: *Glenn T. Seaborg is a legendary name in chemistry today—so well-known and well-beloved, in fact, that C&EN readers gave him the third-highest number of votes in the balloting process that nominated "C&EN's Top 75 Distinguished Contributors to the Chemical Enterprise." Only Linus Pauling and Robert B. Woodward received more votes.*

William Schulz
C&EN, Washington

There is a welcoming sort of clutter in the office of Glenn T. Seaborg—organized piles of books and papers, hundreds of photographs, a stepladder, various desk lamps, and, not surprisingly, several different displays of the periodic table of the elements. He is a busy man still engaged with a career in chemistry and physics that—so far—spans an incredible six decades.

One of his displays of the periodic table—etched onto a glass plate—is an award that highlights in gold leaf the symbol for seaborgium, element 106. It is a potent reminder of Seaborg's legacy in the chemical sciences. In addition to being the discoverer of plutonium, he is the only chemist to hold patents on chemical elements (americium, curium). His revision of the periodic table—the actinide concept—still stands as the most significant since Mendeleyev's 19th-century design. Today, his research associates at Lawrence Berkeley National Laboratory in Berkeley, Calif., are engaged in the search for new isotopes and new elements at the upper end of the periodic table, including the so-called superheavy elements.

Seaborg likes to joke that the controversy surrounding the naming of element 106 mostly had to do with the fact that, at 85 years old, he is still very much alive. At the least, it is Seaborg's way of making sense of the spasm of political correctness that nearly derailed the international process of naming new elements and that nearly denied him and other pioneers of nuclear chemistry honors they deserved.

But the joke is also a display of the humility and somewhat self-deprecating sense of humor characteristic of this Nobel Laureate. In a few words, he signals that he has cast aside any resentment he may have felt about those events. Scorn he could righteously deliver is vanquished with a good-natured referendum on his robust health and longevity.

Reviewing Seaborg's lifetime of achievement in chemistry, government service, and academe, such largess might seem a learned diplomatic skill. But getting to know him through his numerous books, articles, speeches, and interviews, it seems that, for Seaborg, a certain humility has always been his approach to science and the power of scientific truth and discovery.

"Gosh, they picked me?" is his genuine response when informed that readers of *Chemical & Engineering News* voted him among the top three chemists of the past 75 years. Considering his lifetime of accomplishments—which in addition to his scientific discoveries include chancellorship of the University of California, Berkeley (1958–61); chairman of the U.S. Atomic Energy Commission; and president of the American Chemical Society (1976), to name just a few—the vote is not at all surprising. The consummate scholar, Seaborg is honored by this consensus of his peers.

Glenn Theodore Seaborg was born on April 19, 1912, in Ishpeming, Mich., a small iron-mining town on the upper peninsula. It was his father's birthplace and the town to which his Swedish mother had immigrated in 1904. Seaborg recalls learning first to speak and understand Swedish, although he says his facility with the language has since declined.

But Seaborg has never lost touch with his Swedish roots. He lists among his major awards the Great Swedish Heritage Award from the Swedish Council of America and the John Ericsson Gold Medal from the American Society of Swedish Engineers. Among his many friends, he counts another Swedish American—dancer and actress Ann-Margret.

At his mother's urging, when Seaborg was 10 years old, the family moved to the Los Angeles suburb of Home Gardens (now South Gate). The requirement to take a laboratory science in his junior year of high school, Seaborg says, kindled his interest in science, particularly chemistry.

That course was taught by Dwight L.

Photo by Carlos Gonzalez

Reid, who "not only taught chemistry, he preached it." In his senior year, Seaborg studied physics with Reid and "since then my interests in physics and chemistry have been inseparable." There were many other teachers who further inspired Seaborg.

And Seaborg has long been outspoken about science education and the need for more teachers with Reid's passion. Seaborg served on the National Commission on Excellence in Education, which published its famous report, "A Nation at Risk," in 1983. More recently, Seaborg and several other Nobel Laureates produced a report for the state of California that criticized an emphasis on pedagogy over scientific training for teachers.

In 1929, he enrolled at the University of California, Los Angeles, where he majored in chemistry and took the maximum number of courses possible in physics.

Having distinguished himself as an undergraduate, Seaborg was quickly accepted to the highly competitive graduate program in chemistry at UC Berkeley. "It is difficult to describe the exciting, glamorous atmosphere that existed at Berkeley when I entered as a graduate student in 1934," he says. Along with the legendary Gilbert N. Lewis—"the Chief"—as dean of the college of chemistry and chemical engineering, his instructors included such eminent chemists as Axel R. Olson and William F. Giauque. In physics, he particularly recalls the Physics Journal Club where he mixed with the likes of Ernest O. Lawrence, J. Robert Oppenheimer, and Luis W. Alvarez.

Gilman Hall at UC Berkeley during the Lewis era is writ large in the history of chemistry. And so it is in Seaborg's life as well. After receiving his Ph.D. degree in chemistry, he worked there for two years as Lewis' personal research assistant. After joining the faculty as an instructor, he began a collaboration with physicist John J. (Jack) Livingood in which Seaborg chemically identified radioisotopes produced by material Livingood bombarded with deuterons and neutrons. Over the course of five years, they discovered a number of radioisotopes, including iodine-131, iron-59, and cobalt-60.

Although Seaborg's interest in transuranium elements had been piqued by the work of Enrico Fermi and his group in Italy, starting in 1934, Seaborg credits his work with Livingood as cementing the idea that the field would become his life's work. In 1940, element 93—neptunium, the first transuranium element—was identified by colleagues Edwin M. McMillan and Philip H. Abelson.

McMillan was then called away to the East Coast for research related to the war effort. With McMillan's permission, Seaborg and his group went about creating and chemically identifying the next transuranium element, number 94—plutonium. Four years later, he published his concept of the actinide series, and in 1951 he was awarded the Nobel Prize in Chemistry.

Soon after the discovery of plutonium, Seaborg and several of his colleagues were also called into the war effort, namely the supersecret Manhattan Project to build an atomic bomb. His work for the U.S. government began at UC Berkeley, although he would move in 1942 to the University of Chicago, where he directed the work on the chemical processes for the production of plutonium for use in an atomic weapon.

After a little less than two months in Chicago, Seaborg returned briefly to Berkeley where he was reunited with Ernest Lawrence's secretary, Helen L. Griggs, whom he had been dating. "We had a hell of a time getting married," Seaborg says of the frantic pace of life during the war years, but the young couple managed to tie the knot in Pioche, Nev., on June 6, 1942, en route back to Chicago. Today, they are often together during Seaborg's many public appearances.

As he has been since the Manhattan Project became public knowledge, Seaborg is outspoken about the use of atomic power, especially its beneficial uses. For him and other scientists, the Manhattan Project proceeded because of a very real threat: "We thought we were in a race with Hitler and his scientists. We thought Germany would beat us to the atomic bomb," he says emphatically.

With the end of the war in Europe, however, Seaborg became a signer of the 1945 Franck Report—named for James Franck, chairman of the committee that produced it—which recommended a demonstration of the atomic bomb with hopes that this act would persuade Japan to surrender. "We're not sure this report ever reached President Truman," Seaborg says. But he adds, "The bomb did end the war abruptly, and it saved thousands of lives on both sides."

After World War II, Seaborg returned to UC Berkeley and continued his research, including discovery of nine more transuranium elements. Seaborg also became committed to promoting science and a scientifically literate society, curtailing the proliferation of nuclear weapons, and calling for openness in government in the handling of scientific information. He set ambitious goals that have often met with success, though perhaps not always on Seaborg's preferred timetable.

In 1961, President John F. Kennedy tapped Seaborg to become chairman of the Atomic Energy Commission (AEC)—a position he would be reappointed to for the next 10 years. He advocated a complete test ban treaty on atomic weapons under Kennedy, for whom he had traveled to Moscow for negotiations with the Soviet Union. Those talks resulted in a partial test ban. He has written three books about his service with AEC, an insider's account of the Cold War.

In an odd twist of fate, Seaborg—with perhaps unprecedented experience in government secrecy—has had to sound a call for reason in the process of classifying scientific information. In the early 1980s, the Department of Energy "borrowed" his daily journal from his decade of service with AEC, purportedly to write a history of the commission.

Although the journal had passed secrecy checks at the time of his departure from the agency in 1971, DOE saw fit to reclassify major portions of it and has never returned the original. Finally, last year, Seaborg was supported by Sen. Daniel P. Moynihan (D-N.Y.), who in September 1997 introduced a bill, S. 1232, to try to get the uncensored version returned to Seaborg. "I think it's about the worst thing that's ever happened to me," he says.

Despite that experience—or perhaps because of it—Seaborg advocates scientists taking a more active role in the political process. His most recent book, "A Chemist in the White House: From the Manhattan Project to the End of the Cold War" (ACS Books, 1998), is his own account of his government service and a testament to the positive influence scientists can exert on public policy.

In his unassuming office in building 70A of Lawrence Berkeley National Lab, Seaborg continues his life's work. "He never misses a day," his administrator confides. Along with improved science education and public support of science, Seaborg hopes to see more international cooperation among scientists in the decades to come. His outlook for chemistry is particularly bright, agreeing with many that the discipline is poised to make great contributions at the interfaces with biology and other disciplines. Seaborg's own contributions—to science, government, and academe—will surely have great impact for generations to come.◀

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Contributors to the Chemical Enterprise

C&EN's Top 75

Editor's Note: *Over the course of three months in 1997, we asked C&EN readers to nominate their choices for C&EN's "Top 75 Distinguished Contributors to the Chemical Enterprise" during the 75 years of C&EN's existence. Using a ballot in the magazine, readers could nominate up to 20 people, living or dead. We urged nominators to think broadly and globally. Readers nominated more than 1,200 individuals. The result—a readers' choice of "C&EN's Top 75"—follows. The list was compiled and researched by Diana Slade and Maureen Rouhi at C&EN headquarters in Washington, D.C.*

The top four vote getters by far were Linus Pauling, Robert B. Woodward, Glenn Seaborg, and Wallace Carothers. After that, the votes were close. The list includes 32 living scientists and contains 35 Nobel Prize winners, 28 recipients of the American Chemical Society's prestigious Priestley Medal, and 10 winners of the ACS Arthur C. Cope Award. Collectively, the group holds 25 National Medals of Science and three National Medals of Technology. The list is a "Who's Who" of outstanding researchers, people who helped transform the nature of the chemical industry, and influential teachers.

Readers have come up with a superlative group of contributors, representing the diversity within the far-flung chemical enterprise. Chemistry is an endeavor populated by an extraordinarily large number of exceptionally talented people. Thus, it is inevitable that the list does not contain all the many well-known and brilliant contributors to the chemical enterprise—including many Nobel Prize winners—in industry, academe, and government.

C&EN's goal in its 75th anniversary year is to highlight the important contributions that chemists and chemical engineers have made to society at large. We thank our readers for helping us do just that, we salute all of the contributors to the chemical enterprise, and we invite you to attend the Presidential Event at the ACS national meeting in Boston on Aug. 23, where ACS President Paul H. L. Walter will celebrate and honor C&EN's Top 75.

Roger Adams
Jan. 2, 1889–July 6, 1971; born in Boston
Education: A.B., 1909; A.M., 1910; Ph.D., 1912; all from Harvard University
Major contributions: Developed method for preparing uniformly active palladium and platinum catalysts; structural elucidation of natural compounds; toxic alkaloids; organic synthesis; synthetic polymers; studies in steric hindrance and racemization; directed 184 doctoral theses
Major prizes: 1946 Priestley Medal; 1964 National Medal of Science; member, National Academy of Sciences

Alfred Bader
Born April 28, 1924, in Vienna, Austria
Education: B.S., 1945, Queen's University, Kingston, Ontario; B.A., 1946, Queen's University; M.S., 1947, Queen's University; M.A., 1949, Harvard University; Ph.D., chemistry, 1950, Harvard University
Major contributions: Founded Aldrich Chemical Co. in 1951; cofounded Sigma-Aldrich Corp. in 1975
Major prizes: 1995 ACS Charles Lathrop Parsons Award; 1997 Gold Medal of the American Institute of Chemists

Derek Harold Richard Barton
Born Sept. 8, 1918, in Gravesend, Kent, England
Current affiliation: Texas A&M University, College Station
Education: B.S., 1940; Ph.D., organic chemistry, 1942; D.Sc., organic chemistry, 1949; all from Imperial College, London
Major contributions: Pyrolysis of chlorinated hydrocarbons; molecular rotation correlations; conformational analysis; phenolic radical coupling and biosynthesis; invention of radical reactions; selective functionalization of saturated hydrocarbons
Major prizes: 1969 Nobel Prize in Chemistry; 1959 ACS Roger Adams Medal (first awardee); 1971 Award in Natural Product Chemistry of the Chemical Society of London (first awardee); 1995 Priestley Medal; 1995 Lavoisier Medal of the French Chemical Society

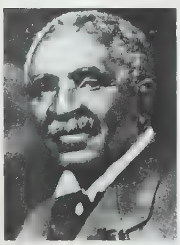
Arnold Orville Beckman
Born April 10, 1900, in Cullom, Ill.
Education: B.S., 1922, University of Illinois; M.S., 1923, University of Illinois; Ph.D., photochemistry, 1928, California Institute of Technology
Major contributions: Developed pH meter; founded Beckman Instruments
Major prizes: 1988 National Medal of Technology; 1989 National Medal of Science; member, National Academy of Engineering

Ronald C. D. Breslow
Born March 14, 1931, in Rahway, N.J.
Current affiliation: Columbia University
Education: A.B., 1952; A.M., 1953; Ph.D., chemistry, 1955; all from Harvard University
Major contributions: First extended monocyclic aromaticity away from six π electron cases; proposed and demonstrated antiaromaticity; discovered chemical and biochemical reaction mechanisms; invented effective artificial enzymes; invented biomimetic functionalization methods; applied hydrophobic effect to chemical synthesis and mechanisms; invented electrochemical methods for carbon cation, radical, and anion energies; invented novel cytodifferentiation agents
Major prizes: 1987 ACS Arthur C. Cope Award; 1989 National Academy of Sciences Award in Chemical Sciences; 1990 Swiss Chemical Society Paracelsus Medal; 1991 National Medal of Science; member, National Academy of Sciences

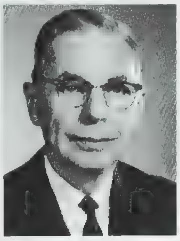
Herbert C. Brown
Born May 22, 1912, in London
Current affiliation: Purdue University, West Lafayette, Ind.
Education: B.S., 1936; Ph.D., inorganic chemistry, 1938; both from University of Chicago
Major contributions: Diborane as facile reducing agent to aldehydes, ketones, and carboxylic acids; discovered simple synthetic routes to diborane and sodium borohydride; explored steric effects and chemical effects of steric strains; discovered hydroboration, providing ready synthesis of organoboranes; developed versatile chemistry of organoboranes; developed a general asymmetric synthesis to pure enantiomers
Major prizes: 1979 Nobel Prize in Chemistry; 1969 National Medal of Science; 1981 Priestley Medal; 1998 ACS H. C. Brown Award for Creative Work on Synthetic Methods (first awardee); member, National Academy of Sciences

Melvin Calvin
April 8, 1911–Jan. 8, 1997; born in St. Paul, Minn.
Education: B.S., 1931, Michigan College of Mining & Technology; Ph.D., chemistry, 1935, University of Minnesota
Major contributions: Pathway of carbon in photosynthesis; organic molecular structure and behavior; coordination catalysis of metalloporphyrins
Major prizes: 1961 Nobel Prize in Chemistry; 1978 Priestley Medal; 1989 National Medal of Science; member, National Academy of Sciences

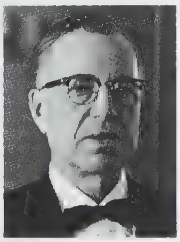
Wallace Hume Carothers
April 27, 1896–April 29, 1937; born in Burlington, Iowa
Education: B.S., 1920, Tarkio College, Missouri; M.S., 1921, University of Illinois; Ph.D., chemistry, 1924, University of Illinois
Major contributions: Development of neoprene and nylon at DuPont



George Washington Carver
early 1860s–Jan. 5, 1943; born in Diamond Grove, Mo.
Education: B.S., 1894; M.S., 1896; both from Iowa Agricultural College
Major contributions: Developed industrial applications for farm products such as peanuts, sweet potatoes, and pecans; derived a rubber substitute and more than 500 dyes and pigments from 28 different plants; paints and stains from soybeans



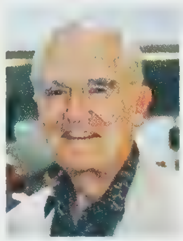
James Bryant Conant
March 26, 1893–Feb. 11, 1978; born in Dorchester, Mass.
Education: B.S., 1913; Ph.D., 1916; both from Harvard University
Major contributions: Pioneer in physical chemistry; acid-base catalysis; existence of superacids; director of National Defense Research Committee during World War II; established coeducation at Harvard University; author of books on public education
Major prizes: 1944 Priestley Medal



Arthur Clay Cope
June 27, 1909–June 4, 1966; born in Dunreith, Ind.
Education: Bachelor's degree, 1929, Butler University, Indianapolis; Ph.D., 1932, University of Wisconsin
Major contributions: Chemistry of medium-sized ring compounds; transannular reactions; rearrangement of allyl groups in three-carbon systems; work in synthetic organic chemistry
Major prizes: 1965 ACS Roger Adams Award in Organic Chemistry

Elias James Corey
Born July 12, 1928, in Methuen, Mass.
Current affiliation: Harvard University
Education: B.S., 1948; Ph.D., chemistry, 1951; both from Massachusetts Institute of Technology
Major contributions: Development of the fundamental logic of chemical synthesis and many generally useful reactions and methods for synthesis; achievement of total synthesis of more than 100 complex, biologically active molecules; use of computers in chemistry; theory and stereochemistry of organic reactions; stereoelectronic effects in organic reactions; importance of orbital symmetry in control cycloaddition and pericyclic reactions; enantioselective catalysis
Major prizes: 1990 Nobel Prize in Chemistry; 1976 ACS Arthur C. Cope Award; 1986 Wolf Prize; 1988 National Medal of Science; member, National Academy of Sciences

F. Albert Cotton
Born April 9, 1930, in Philadelphia
Current affiliation: Texas A&M University, College Station
Education: A.B., 1951, Temple University; Ph.D., chemistry, 1955, Harvard University
Major contributions: Work in inorganic chemistry, protein chemistry, structural chemistry, and chemical bonding; originator of the field of compounds containing single and multiple bonds between metal atoms; contributed in the fields of protein structure, spectroscopic studies of metal carbonyls, and dynamic behavior of fluxional organometallic and metal carbonyl compounds
Major prizes: 1982 National Medal of Science; 1990 National Academy of Sciences Award in Chemical Sciences; 1994 Welch Award in Chemistry; 1998 Priestley Medal; member, National Academy of Sciences



Donald J. Cram
Born April 22, 1919, in Chester, Vt.
Current affiliation: University of California, Los Angeles
Education: B.S., 1941, Rollins College; M.S., 1942, University of Nebraska; Ph.D., organic chemistry, 1947, Harvard University
Major contributions: Application of stereochemical techniques to organic reaction mechanisms (for example, phenonium ions, Cram's rule, asymmetric solvation of carbanions); introduced cyclophane transannular effect studies; introduced host-guest synthetic organic chemical binding systems as models for biological processes; studied structural and chiral recognition in binding; invented carceplexes (guest molecules completely encapsulated by hosts)
Major prizes: 1987 Nobel Prize in Chemistry; 1974 ACS Arthur C. Cope Award; 1992 National Academy of Sciences Award in Chemical Sciences; 1993 National Medal of Science; member, National Academy of Sciences

Francis Harry Compton Crick
Born June 8, 1916, in Northampton, England
Current affiliation: Salk Institute of Biological Studies, San Diego
Education: B.S., 1937, University College, London; Ph.D., 1954, Cambridge University
Major contributions: Determined structure of DNA; studies of mammalian brain
Major prizes: 1962 Nobel Prize in Physiology or Medicine; foreign associate, National Academy of Sciences

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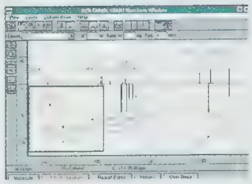

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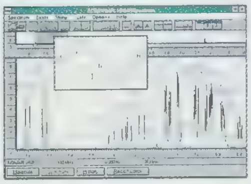

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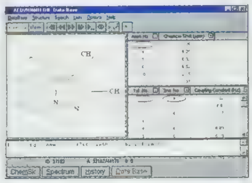

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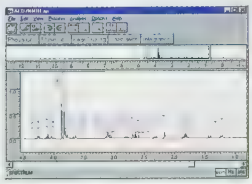

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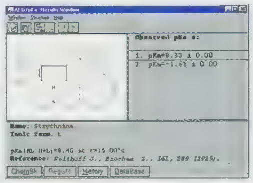

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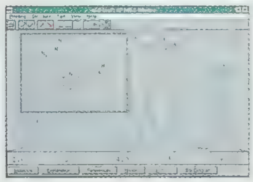

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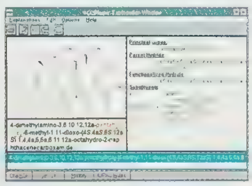

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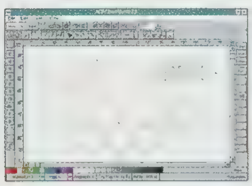

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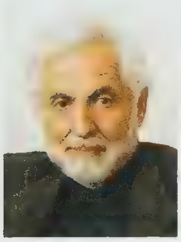
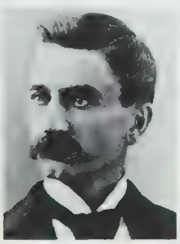
Marie Curie
Nov. 7, 1867–July 4, 1934; born in Warsaw, Poland
Education: Master's degree, 1894, Sorbonne
Major contributions: Discovery of radioactivity; discovery of radium and polonium
Major prizes: 1903 Nobel Prize in Physics; 1911 Nobel Prize in Chemistry

Peter Joseph William Debye
March 24, 1884–Nov. 2, 1966; born in Maastricht, the Netherlands
Education: Bachelor's degree, 1905, Technische Hochschule, Aachen; Ph.D., physics, 1908, Ludwig-Maximilian University
Major contributions: Determination and definition of dipole moment; powder method of X-ray diffraction
Major prizes: 1936 Nobel Prize in Chemistry; 1963 Priestley Medal



Carl Djerassi
Born Oct. 29, 1923, in Vienna, Austria
Current affiliation: Stanford University
Education: A.B., 1942, Kenyon College, Gambier, Ohio; Ph.D., organic chemistry, 1945, University of Wisconsin, Madison
Major contributions: Structure elucidation of natural products (antibiotics, alkaloids, steroids, and terpenoids); synthesis of medicinals (antihistamines, anti-inflammatory agents, oral contraceptives, hormone analogs); applications of physical measurements (notably optical rotatory dispersion, magnetic circular dichroism, and mass spectrometry) and computer artificial intelligence techniques to organic chemical problems
Major prizes: 1973 National Medal of Science; 1973 ACS Award for Creative Invention; 1978 Wolf Prize in Chemistry; 1991 National Medal of Technology; 1992 Priestley Medal; member, National Academy of Sciences



Herbert Henry Dow
Feb. 26, 1866–Oct. 15, 1930; born in Belleville, Ontario
Education: Bachelor's degree, 1888, Case Institute of Applied Science
Major contributions: Formed Dow Chemical Co. in 1897; reinvented manufacturing process for bromine and other industrial chemicals; helped to break stranglehold of powerful European cartels

Pierre Samuel DuPont
Jan. 15, 1870–April 5, 1954; born in Wilmington, Del.
Education: Bachelor's degree, 1890, Massachusetts Institute of Technology
Major contributions: Worked at DuPont 1902–20; president of DuPont 1915–20; transformed the premier U.S. explosives maker, E. I. du Pont de Nemours, into the well-known diversified chemical producer

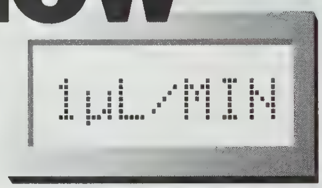
George Eastman
July 2, 1854–March 14, 1932; born in Waterville, N.Y.
Major contributions: Process for making dry plates for photography and a machine to make large numbers of dry plates; established Eastman Dry Plate & Film Co. in 1884, which became Eastman Kodak in 1892; developed transparent film and Brownie camera with removable film

Ernest L. Eliel
Born Dec. 28, 1921, in Cologne, Germany
Current affiliation: University of North Carolina, Chapel Hill
Education: B.S., 1946, University of Havana; Ph.D., chemistry, 1948, University of Illinois, Urbana-Champaign
Major contributions: Organic stereochemistry and conformational analysis, including three landmark books: "Stereochemistry of Carbon Compounds" (1962), "Conformational Analysis" (1965, coauthored), "Stereochemistry of Organic Compounds" (1994, with S. H. Wilen); coeditor of *Topics in Stereochemistry* (1965–94)
Major prizes: 1968 Lavoisier Medal of the French Chemical Society; 1995 ACS George C. Pimentel Award in Chemical Education; 1996 Priestley Medal; 1997 National Academy of Sciences Award for Chemistry in Service to Society; member, National Academy of Sciences

Gertrude B. Elion
Born Jan. 23, 1918, in New York City
Current affiliation: Glaxo Wellcome
Education: B.A., 1937, Hunter College; M.S., chemistry, 1941, New York University
Major contributions: Rational design, synthesis, and development of therapeutic agents: 6-mercaptopurine and 6-thioguanine for the treatment of acute leukemia and azathioprine for the prevention of kidney transplant rejection; played a major role in the development of allopurinol for the treatment of gout; acyclovir, a selective antiviral agent for herpes virus infections
Major prizes: 1988 Nobel Prize in Physiology or Medicine; 1968 ACS Francis P. Garvan Medal; 1991 National Medal of Science; 1997 Lemelson/Massachusetts Institute of Technology Lifetime Achievement Award; member, National Academy of Sciences

Henry Eyring
Feb. 20, 1901–Dec. 26, 1981; born in Colonia Juarez, Mexico
Education: B.S., 1923, University of Arizona; M.S., 1924, University of Arizona; Ph.D., chemistry, 1927, University of California, Berkeley
Major contributions: Transition-state theory; chemical kinetics; construction of first potential energy surface for a reaction
Major prizes: 1975 Priestley Medal; member, National Academy of Sciences

Louis Frederick Fieser
April 7, 1899–July 25, 1977; born in Columbus, Ohio
Education: B.A., 1920, Williams College; Ph.D., 1924, Harvard University
Major contributions: Chemistry of aromatic compounds, especially quinones and hydroquinones; new synthetic route to anthraquinones; synthesis of vitamin K; identification of carcinogens; "Steroids" reference work; coauthor of 17-volume series "Reagents for Organic Synthesis"
Major prizes: Member, National Academy of Sciences



Mary Fieser
May 27, 1909–March 22, 1997; born in Atchison, Kan.
Education: Bachelor's degree, 1930, Bryn Mawr College; M.S., organic chemistry, Radcliffe College
Major contributions: Research on quinones, natural products, steroids; coauthored "Basic Organic Chemistry," "Advanced Organic Chemistry," "Style Guide for Chemists," "Steroids," and 17-volume series "Reagents for Organic Synthesis"

Paul John Flory
July 19, 1910–Sept. 8, 1985; born in Sterling, Ill.
Education: B.S., 1931, Manchester College; Ph.D., 1934, Ohio State University
Major contributions: Physical chemistry of macromolecules; solved excluded-volume problem of polymers in solution; spatial configuration of chain molecules; thermodynamics of solutions; authored "Principles of Polymer Chemistry"
Major prizes: 1974 Nobel Prize in Chemistry; 1974 Priestley Medal

Mary Lowe Good
Born June 20, 1931, in Grapevine, Texas
Current affiliation: Venture Capital Investors Inc.
Education: B.S., 1950, University of Central Arkansas; M.S., 1953, University of Arkansas; Ph.D., chemistry, 1955, University of Arkansas
Major contributions: Served in research and leadership positions at Louisiana State University and at AlliedSignal; provided science and technology advice and leadership as undersecretary for technology of the Department of Commerce, member of the National Science Board, and chairman of the President's Council of Advisers on Science & Technology; leadership in ACS as a board member and as 1987 ACS president
Major prizes: 1992 National Science Foundation Distinguished Public Service Award; 1995 honorary fellowship, Royal Society of Chemistry; 1996 ACS Earle B. Barnes Award for Leadership in Chemical Research Management; 1997 Priestley Medal; member, National Academy of Engineering

Harry B. Gray
Born Nov. 14, 1935, in Woodburn, Ky.
Current affiliation: California Institute of Technology
Education: B.S., 1957, Western Kentucky University; Ph.D., chemistry, 1960, Northwestern University
Major contributions: Landmark work on the electronic structures of inorganic compounds and metalloproteins; on inorganic spectroscopy and photochemistry, particularly for complexes containing metal-metal bonds; and on the mechanisms of inorganic and bioinorganic reactions; cofounder of the field of bioinorganic chemistry; pioneered the study of electron transfer in proteins
Major prizes: 1986 National Medal of Science; 1986 Linus Pauling Medal; 1988 California Scientist of the Year; 1991 Priestley Medal; member, National Academy of Sciences

Louis Plack Hammett
April 7, 1894–Feb. 23, 1987; born in Wilmington, Del.
Education: A.B., 1916, Harvard University; Ph.D., 1923, Columbia University
Major contributions: Quantitative structure-activity relationships (QSAR); correlation of electronic properties of acids and bases with equilibrium constants and reactivity; developed Hammett equation for linear free-energy relationships and the correlation of changes in chemical properties with chemical structure
Major prizes: 1961 Priestley Medal; 1967 National Medal of Science; member, National Academy of Sciences

Dudley Robert Herschbach
Born June 18, 1932, in San Jose, Calif.
Current affiliation: Harvard University
Education: B.S., 1954, Stanford University; M.S., 1955, Stanford University; A.M., 1956, Harvard University; Ph.D., chemical physics, 1958, Harvard University
Major contributions: Development of molecular beam methods for study of elementary chemical reaction dynamics
Major prizes: 1986 Nobel Prize in Chemistry; 1991 National Medal of Science; member, National Academy of Sciences

Joel Henry Hildebrand
Nov. 16, 1881–April 30, 1983; born in Camden, N.J.
Education: B.S., 1903; Ph.D., 1906; both from the University of Pennsylvania
Major contributions: Behavior of liquids and nonelectrolyte solutions; authored "Principles of Chemistry" textbook; science education
Major prizes: 1962 Priestley Medal; 1952 ACS Award in Chemical Education; member, National Academy of Sciences

Dorothy Mary Crowfoot Hodgkin
May 12, 1910–July 30, 1994; born in Cairo, Egypt
Education: Bachelor's degree, 1932, Somerville College, Oxford, England; Ph.D., 1937, Cambridge University
Major contributions: Use of X-ray diffraction techniques to determine the structure of complex compounds including vitamin B-12, penicillin, and insulin
Major prizes: 1964 Nobel Prize in Chemistry

Roald Hoffmann
Born July 18, 1937, in Zloczow, Poland
Current affiliation: Cornell University
Education: B.A., 1958, Columbia College; M.A., 1960, Harvard University; Ph.D., chemical physics, 1962, Harvard University
Major contributions: Established qualitative molecular-orbital-based ways of thinking about the electronic and geometrical structure and reactivity of all molecules—organic, inorganic, organometallic, surface, and extended structures; rules for predicting course of pericyclic reactions
Major prizes: 1981 Nobel Prize in Chemistry; 1973 ACS Arthur C. Cope Award; 1983 National Medal of Science; 1986 National Academy of Sciences Award in the Chemical Sciences; 1990 Priestley Medal; member, National Academy of Sciences

Christopher Kelk Ingold
Oct. 28, 1893–Dec. 8, 1970; born in London
Education: B.S., 1913, University of Southampton, England; M.S., 1913, Imperial College, London; D.Sc., 1919, Imperial College, London
Major contributions: Electronic theory of organic reaction mechanisms; structure and mechanism in organic chemistry; terminology of physical organic chemistry; sequence rules for defining absolute configuration
Major prizes: Fellow, Royal Society of Chemistry

William Summer Johnson
Feb. 24, 1913–Aug. 19, 1995; born in New Rochelle, N.Y.
Education: A.B., 1936, Amherst College; A.M., 1938, Harvard University; Ph.D., 1940, Harvard University
Major contributions: New and more efficient ways to synthesize complex molecules, including corticoid steroids
Major prizes: 1987 National Medal of Science; 1989 ACS Arthur C. Cope Award; member, National Academy of Sciences

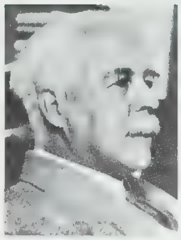
Irène Joliot-Curie
Sept. 12, 1897–March 17, 1956; born in Paris
Education: Bachelor's degree, 1914, Collège Sévigné; doctorate, 1920, Sorbonne
Major contributions: Discovery of artificial radioactivity; her work led to the discovery of the neutron and fission
Major prizes: 1935 Nobel Prize in Chemistry

Percy Lavon Julian
April 11, 1899–April 19, 1975; born in Montgomery, Ala.
Education: B.S., 1920, DePauw University; M.S., 1923, Harvard University; Ph.D., 1931, University of Vienna
Major contributions: Synthesis of physostigmine and cortisone
Major prizes: Member, National Academy of Sciences

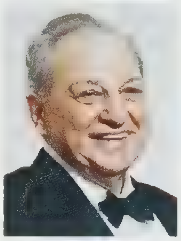
Ralph Landau
Born May 19, 1916, in Philadelphia
Current affiliation: Listowel Inc.
Education: B.S., 1937, University of Pennsylvania; Sc.D., chemical engineering, 1941, Massachusetts Institute of Technology
Major contributions: Cofounded Scientific Design in 1946; led company in development of the current terephthalic acid process used in most polyester manufacture; the propylene oxide process used in many urethane products; and cyclohexane oxidation, which is used in many nylon precursor operations
Major prizes: 1973 Chemical Industry Medal; 1981 Perkin Medal; 1985 National Medal of Technology; 1997 Othmer Medal of the Chemical Heritage Foundation; member, National Academy of Engineering

Irving Langmuir
Jan. 31, 1881–Aug. 16, 1957; born in Brooklyn
Education: Bachelor's degree, 1903, Columbia University School of Mines; Ph.D., 1906, University of Göttingen
Major contributions: Invention of high-vacuum electron tube and gas-filled incandescent lamp; development of modern surface chemistry; theory of adsorption catalysis; discovery of monomolecular films; molecular orientation at surfaces; understanding of plasmas, heat transfer, and thermionic phenomena
Major prizes: 1932 Nobel Prize in Chemistry; fellow, Royal Society of Chemistry; member, National Academy of Sciences

Jean-Marie Lehn
Born Sept. 30, 1939, in Rosheim, Alsace, France
Current affiliation: Collège de France
Education: B.S., 1960; Ph.D., 1963; both from the University of Strasbourg
Major contributions: Supramolecular chemistry: cryptates, molecular recognition, molecular receptors and coreceptors, supramolecular catalysis; transport processes; self-assembly and self-organization; supramolecular materials; chemionics: molecular photonic, electronic, and ionic devices; semiochemistry; two books, including "Supramolecular Chemistry: Concepts and Perspectives" (1997)
Major prizes: 1987 Nobel Prize in Chemistry; 1982 Swiss Chemical Society Paracelsus Medal; 1997 Lavoisier Medal of the French Chemical Society; 1997 Davy Medal of the Royal Society; foreign associate, National Academy of Sciences



Gilbert Newton Lewis
Oct. 23, 1875–March 23, 1946; born in Weymouth, Mass.
Education: A.B., 1896; M.A., 1898; Ph.D., 1899; all from Harvard University
Major contributions: Theory of chemical bonding and valence, based on concept of shared electron pair; acids and bases as electron pair acceptors and donors

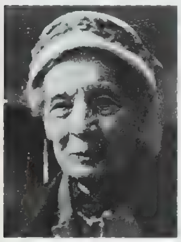


Rudolph Arthur Marcus
Born July 21, 1923, in Montreal, Quebec
Current affiliation: California Institute of Technology
Education: B.Sc., 1943; Ph.D., chemistry, 1946; both from McGill University
Major contributions: Marcus theory of electron-transfer reactions in chemical, electrochemical, and biological systems; RRKM (Rice-Ramsperger-Kassel-Marcus) theory of unimolecular reactions and bimolecular association reactions; semiclassical and intramolecular dynamics of reactions
Major prizes: 1992 Nobel Prize in Chemistry; 1985 Wolf Prize in Chemistry; 1989 National Medal of Science; foreign member, Royal Society of London; member, American Philosophical Society

Herman F. Mark
May 3, 1895–April 6, 1992; born in Vienna, Austria
Education: Ph.D., 1921, University of Vienna
Major contributions: Development of polymer science; structural determination of natural polymers; development of new polymers, including polyvinyls and polyacrylics
Major prizes: Member, National Academy of Sciences

Carl (Speed) Marvel
Sept. 11, 1894–Jan. 4, 1988; born in Waynesville, Ill.
Education: B.S., 1915, Illinois Wesleyan University; M.S., 1915, Illinois Wesleyan University; Ph.D., 1920, University of Illinois
Major contributions: Development of polymer science; vinyl polymers; high-temperature-resistant polymers
Major prizes: 1956 Priestley Medal; member, National Academy of Sciences

Samuel Proctor Massie Jr.
Born July 3, 1919, in North Little Rock, Ark.
Current affiliation: U.S. Naval Academy, Annapolis, Md.
Education: B.S., 1938, A.M.N. College, Arkansas; M.A., 1940, Fisk University; Ph.D., organic chemistry, 1946, Iowa State University
Major contributions: Studies in silicon chemistry; chemistry of phenothiazine; antimalarial-antibacterial agents; studies on environmental agents; encouraging disadvantaged students into science careers; Samuel P. Massie Chair of Excellence Program established in 1994 by the Department of Energy committing $14.7 million in grants over a five-year period to nine historically black colleges and universities and one Hispanic-serving institution
Major prizes: 1980 NOBCChE Teaching Award; 1994 ACS James Flack Norris Award for Outstanding Achievement in Teaching Chemistry; 1996 ACS Award for Encouraging Disadvantaged Students into Careers in the Chemical Sciences



Lise Meitner
Nov. 7, 1878–Oct. 27, 1968; born in Vienna, Austria
Education: Ph.D., 1905, University of Vienna
Major contributions: Discovery of protactinium; chemistry of radioactivity; codiscoverer of nuclear fission

R. Bruce Merrifield
Born July 15, 1921, in Fort Worth, Texas
Current affiliation: Rockefeller University
Education: B.A., 1943; Ph.D., biochemistry, 1949; both from University of California, Los Angeles
Major contributions: Conceived and developed solid-phase peptide synthesis and applied it to the chemical synthesis of various growth factors, antibiotics, hormones, and effective antagonists of glucagon; completed the first total synthesis of an enzyme; technique now used for the combinatorial synthesis of peptide and nonpeptide libraries
Major prizes: 1984 Nobel Prize in Chemistry; 1972 ACS Award for Creative Work in Synthetic Organic Chemistry; 1987 Royal Society of Chemistry Medal; 1993 Glenn T. Seaborg Medal; member, National Academy of Sciences

Robert Sanderson Mulliken
June 7, 1896–Oct. 31, 1986; born in Newburyport, Mass.
Education: B.S., 1917, Massachusetts Institute of Technology; Ph.D., 1921, University of Chicago
Major contributions: Codeveloper of molecular orbital theory; electronic structure of molecules
Major prizes: 1966 Nobel Prize in Chemistry; 1983 Priestley Medal; member, National Academy of Sciences

Giulio Natta
Feb. 26, 1903–May 2, 1979; born in Imperia, Liguria, Italy
Education: Dottore degree, 1924; Libero Docente degree, 1927; both from Milan Polytechnic Institute
Major contributions: Discovery and elucidation of stereospecific polymerization and stereoregular polymers; development of commercially important polymerization processes
Major prizes: 1963 Nobel Prize in Chemistry

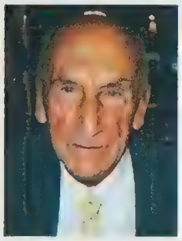
George A. Olah
Born May 22, 1927, in Budapest, Hungary
Current affiliation: University of Southern California
Education: Ph.D., chemistry, 1949, Technical University of Budapest
Major contributions: Study of carbocations as long-lived species in superacids and investigation of related hydrocarbon chemistry, including development of environmentally benign and safe processes; study of new synthetic reagents and methods; structural and mechanistic studies in organic chemistry
Major prizes: 1994 Nobel Prize in Chemistry; 1964 ACS Award in Petroleum Chemistry; 1979 ACS Award for Creative Work in Synthetic Organic Chemistry; 1989 ACS Roger Adams Award in Organic Chemistry; member, National Academy of Sciences

Donald Frederick Othmer
May 11, 1904–Nov. 1, 1995; born in Omaha, Neb.
Education: B.ChE., 1924, University of Nebraska; M.ChE., 1925, University of Michigan, Ann Arbor; Ph.D., chemical engineering, 1927, University of Michigan, Ann Arbor
Major contributions: Cofounder and editor of Kirk-Othmer Encyclopedia of Chemical Technology; development of Polytechnic University of Brooklyn's chemical engineering program; solutions to problems in manufacturing plastics, food, textiles, and pharmaceuticals

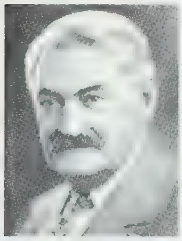
Charles Lathrop Parsons
March 23, 1867–Feb. 13, 1954; born in New Marboro, Mass.
Education: B.S., 1888, Cornell University; D.Sc., 1911, University of Maine
Major contributions: Chemistry of beryllium; organized project to develop an American process for extracting radium from Colorado and Utah carnotite, which led to establishment of National Radium Institute; authority on nitrogen fixation, uranium, and radium; obtained federal charter for ACS; directed gift of ownership of Universal Oil Products Co. into a trusteeship under which ACS administers the Petroleum Research Fund grants
Major prizes: 1932 Priestley Medal

Linus Carl Pauling
Feb. 28, 1901–Aug. 19, 1994; born in Portland, Ore.
Education: Bachelor's degree, 1922, Oregon Agricultural College; Ph.D., 1925, California Institute of Technology
Major contributions: Nature of the chemical bond; valence bond theory; concepts of electronegativity, resonance, and hybridization; application of structural chemistry to biological molecules
Major prizes: 1954 Nobel Prize in Chemistry; 1962 Nobel Peace Prize; 1948 Presidential Medal of Merit for outstanding service during World War II; 1984 Priestley Medal; member, National Academy of Sciences

George Claude Pimentel
May 2, 1922–June 1, 1989; born in Rolinda, Calif.
Education: A.B., 1943, University of California, Los Angeles; Ph.D., 1949, University of California, Berkeley
Major contributions: Development of chemical lasers, matrix isolation techniques, and rapid-scan IR spectroscopy; designed instruments for interplanetary spacecraft; revitalized teaching of chemistry in high schools
Major prizes: 1983 National Medal of Science; 1989 Priestley Medal; member, National Academy of Sciences

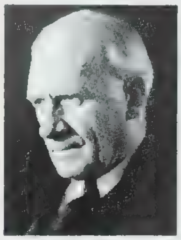


Vladimir Prelog
Born July 23, 1906, in Sarajevo, Czechoslovakia
Current affiliation: Swiss Federal Institute of Technology, Zurich
Education: D.Chem., 1929, Czechoslovakia Institute of Technology
Major contributions: Synthesized adamantane and sulfanilamide; work in alkaloids; elucidated structures for nonactin, boromycin, ferrioxamins, and rifamycins; synthesized medium-sized ring compounds from dicarboxylic acid esters by acyloin condensation
Major prizes: 1975 Nobel Prize in Chemistry; 1969 ACS Roger Adams Award in Organic Chemistry



John Francis Queeny
Aug. 17, 1859–March 19, 1933; born in Chicago
Education: Six years of public school
Major contributions: Founded Monsanto in 1901; first U.S. company to produce saccharin, at a time when German chemical companies were the only commercial source; commercialized a breakthrough in the 1920s of the manufacture of sulfuric acid with a vanadium catalyst instead of the then-usual and expensive platinum catalyst

John D. Roberts
Born June 8, 1918, in Los Angeles
Current affiliation: California Institute of Technology
Education: A.B., 1941; Ph.D., chemistry, 1944; both from the University of California, Los Angeles
Major contributions: Mechanisms of carbocationic and aromatic displacement (benzyne) reactions; chemistry of small-ring compounds; substituent effects on chemical reactivity; molecular orbital calculations; applications of nuclear (especially carbon-13 and nitrogen-15) magnetic resonance spectroscopy to organic chemistry, bioorganic chemistry, and biochemistry
Major prizes: 1987 Priestley Medal; 1989 Welch Award in Chemistry; 1994 ACS Arthur C. Cope Award; member, National Academy of Sciences



Robert Robinson
Sept. 13, 1885–Feb. 8, 1975; born near Chesterfield, Derbyshire, England
Education: Bachelor's degree, 1905, Ph.D., 1909; both from the University of Manchester
Major contributions: Electronic theory of organic reaction mechanisms; total synthesis of natural products, especially alkaloids and steroids; theory of alkaloid biogenesis; structural elucidation of penicillin
Major prizes: 1947 Nobel Prize in Chemistry; 1953 Priestley Medal; fellow, Royal Society of Chemistry; foreign member, National Academy of Sciences

Glenn T. Seaborg
Born April 19, 1912, in Ishpeming, Mich.
Current affiliation: University of California, Berkeley
Education: A.B., 1934, University of California, Los Angeles; Ph.D., chemistry, 1937, University of California, Berkeley
Major contributions: One of the discoverers of plutonium (plutonium-238 and plutonium-239) and headed the Manhattan Project group that devised the chemical extraction processes used in its production; codiscovered nine other transuranium elements, including element 106, seaborgium
Major prizes: 1951 Nobel Prize in Chemistry; 1979 Priestley Medal; 1991 National Medal of Science; 1994 ACS George C. Pimentel Award in Chemical Education; member, National Academy of Sciences

Karl Barry Sharpless
Born April 28, 1941, in Philadelphia
Current affiliation: Scripps Research Institute, La Jolla, Calif.
Education: A.B, 1963, Dartmouth College; Ph.D., organic chemistry, 1968, Stanford University
Major contributions: Discovery and development of many widely used catalytic oxidation processes, notably first general methods for stereoselective oxidation—the Sharpless reactions for the asymmetric epoxidation, dihydroxylation, and aminohydroxylation of olefins
Major prizes: 1983 ACS Award for Creative Organic Synthesis; 1991 Scheele Medal, Sweden; 1992 ACS Arthur C. Cope Award; 1993 Tetrahedron Prize for Creativity in Organic Synthesis; member, National Academy of Sciences

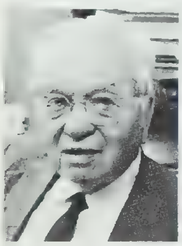
Richard E. Smalley
Born June 6, 1943, in Akron, Ohio
Current affiliation: Rice University, Houston
Education: B.S., 1964, University of Michigan, Ann Arbor; M.A., 1971, Princeton University; Ph.D., 1973, Princeton University
Major contributions: Pioneered advances in development of supersonic beam laser spectroscopy, super-cold pulsed beams, and laser-driven sources of free radicals, triplets, and metal and semiconductor cluster beams; discovered and characterized fullerenes, the third elemental form of carbon; first to generate fullerenes with metals trapped inside carbon cage; studies of carbon nanotubes
Major prizes: 1996 Nobel Prize in Chemistry; 1991 ACS Irving Langmuir Prize in Chemical Physics; 1992 Welch Award in Chemistry; 1993 William H. Nichols Medal; member, National Academy of Sciences

Hermann Staudinger
March 23, 1881–Sept. 9, 1965; born in Worms, Germany
Education: University of Halle, Germany
Major contributions: Principles of macromolecular chemistry; fundamental studies of polystyrene, polyesters, polyamides, vinyl amides, and amino plastics, which laid the foundation for the giant plastics industry today; discovery of ketene
Major prizes: 1953 Nobel Prize in Chemistry

Gilbert Stork
Born Dec. 31, 1921, in Brussels, Belgium
Current affiliation: Columbia University
Education: B.S., 1942, University of Florida; Ph.D., chemistry, 1945, University of Wisconsin
Major contributions: Enamine alkylation and acylation; metalloenamine alkylation; theory of concerted polyene cyclization; regiospecific enolate formulation and kinetic trapping; vinyl radical cyclization; radical holoacetal cyclization in control of regio- and stereochemistry; temporary silicon connection in stereo- and regiocontrol; first stereorational synthesis (cantharidin in 1951)
Major prizes: 1980 ACS Arthur C. Cope Award; 1983 National Medal of Science; 1993 Welch Prize in Chemistry; 1996 Wolf Prize in Chemistry; member, National Academy of Sciences

Henry Taube
Born Nov. 30, 1915, in Neudork, Saskatchewan
Current affiliation: Stanford University
Education: B.Sc., 1935, University of Saskatchewan; Ph.D., 1940, University of California, Berkeley
Major contributions: First determination of the solvation number of cations; correlation of substitution lability of metal complexes with electronic structure; intimate mechanisms of electron transfer in chemical reactions; systematic study of mixed-valence molecules and of back-bonding in relation to properties of metal complexes
Major prizes: 1983 Nobel Prize in Chemistry; 1983 Welch Award in Chemistry; 1985 Priestley Medal; 1985 National Medal of Science; member, National Academy of Sciences

Max Tishler
Oct. 30, 1906–March 18, 1989; born in Boston
Education: Bachelor's degree, 1928, Tufts University; Ph.D., chemistry, 1934, Harvard University
Major contributions: Worked as an industrial chemist at Merck & Co. for 33 years and developed antibiotics, including actinomycin and streptomycin; facilitated commercial production of cortical steroids; synthesized vitamin A and riboflavin; led the Merck team that developed a production process for penicillin during World War II
Major prizes: 1970 Priestley Medal; 1987 National Medal of Science

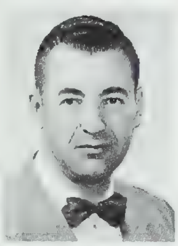


Harold Clayton Urey
April 29, 1893–Jan. 5, 1981; born in Walkerton, Ind.
Education: B.S., 1917, University of Montana; Ph.D., chemistry, 1923, University of California, Berkeley
Major contributions: discovery of deuterium; isotope separation
Major prizes: 1934 Nobel Prize in Chemistry; 1964 National Medal of Science; 1973 Priestley Medal; member, National Academy of Sciences

James Dewey Watson
Born April 6, 1928, in Chicago
Current affiliation: Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y.
Education: B.S., 1947, University of Chicago; Ph.D., 1950, Indiana University
Major contributions: Determined structure of DNA; DNA-protein interactions; role of RNA in protein synthesis
Major prizes: 1962 Nobel Prize in Physiology or Medicine; 1977 Presidential Medal of Freedom; member, National Academy of Sciences

Frank H. Westheimer
Born Jan. 15, 1912, in Baltimore
Current affiliation: Harvard University
Education: A.B., 1932, Dartmouth College; M.A., 1933, Harvard University; Ph.D., chemistry, 1935, Harvard University
Major contributions: Calculation of electrostatic effects in chemistry; molecular mechanics; mechanism of chromic acid oxidations; metal-ion and enzymatic decarboxylations; direct and stereospecific transfer of hydrogen in biochemical oxidation-reduction; pseudorotation in hydrolysis of phosphate esters; invention of photoaffinity labeling
Major prizes: 1980 National Academy of Sciences Award in the Chemical Sciences; 1982 ACS Arthur C. Cope Award; 1986 National Medal of Science; 1988 Priestley Medal; member, National Academy of Sciences

Geoffrey Wilkinson
July 14, 1921–Sept. 26, 1997; born in Todmorden, England
Education: B.Sc., 1941; Ph.D., 1946; both from Imperial College, London
Major contributions: Chemistry of metallocenes; chemistry of phosphorus halides, fluxional compounds, rhenium, rhodium, and ruthenium; chemistry of complex hydrides; mechanism of homogeneous catalytic reactions
Major prizes: 1973 Nobel Prize in Chemistry; fellow, Royal Society; foreign associate, National Academy of Sciences



Saul Winstein
Oct. 8, 1912–Nov. 23, 1969; born in Montreal, Quebec
Education: A.B., 1934, University of California, Los Angeles; M.A., 1935, University of California, Los Angeles; Ph.D., 1938, California Institute of Technology
Major contributions: Mechanisms of organic reactions; physical organic chemistry; ion pairs; homoconjugation; homoaromaticity
Major prizes: 1970 National Medal of Science (awarded posthumously); member, National Academy of Sciences

Georg F. K. Wittig
June 16, 1897–Aug. 26, 1987; born in Berlin, Germany
Education: Ph.D., 1923, University of Marburg/Lahn, Germany
Major contributions: Wittig reaction for conversion of C=O to C=C, which is used to make β-carotene, steroids, juvenile hormones and pheromones, and some prostaglandins and vitamins
Major prizes: 1979 Nobel Prize in Chemistry

Robert Burns Woodward
April 10, 1917–July 8, 1979; born in Boston
Education: Bachelor's degree, 1936; Ph.D., 1937; both from Massachusetts Institute of Technology
Major contributions: Total synthesis of complex natural products, including vitamin B-12; organic structure determination; synthetic methods; biogenetic theory; conservation of orbital symmetry
Major prizes: 1965 Nobel Prize in Chemistry; 1964 National Medal of Science; 1973 ACS Arthur C. Cope Award; member, National Academy of Sciences

Rosalyn Sussman Yalow
Born July 19, 1921, in New York City
Current affiliation: Veterans Administration Hospital, Bronx, N.Y.
Education: A.B., Hunter College, 1941; Ph.D., 1945, University of Illinois, Urbana
Major contributions: Developed technique of radioimmunoassay
Major prizes: 1977 Nobel Prize in Physiology or Medicine

Karl Ziegler
Nov. 26, 1898–Aug. 11, 1973; born in Helsa, Germany
Education: Ph.D., 1920, Marburg University
Major contributions: Controlled polymerization of hydrocarbons through organometallic catalysts; catalytic system enabling low-pressure polymerization of ethylene to linear polyethylene; chemistry of carbon compounds; development of plastics
Major prizes: 1963 Nobel Prize in Chemistry

75 Years Of Facts & Figures

Michael Heylin
C&EN Washington
George Peaff
C&EN Northeast News Bureau

Since 1948, C&EN's editorial lineup has included its annual Facts & Figures for the Chemical Industry feature. This has long been the most exhaustive compilation of industry statistics published in any magazine. Since 1979, C&EN has also presented each year the companion Facts & Figures for Chemical R&D. So this special C&EN issue celebrating the 1923–98 era of the chemical enterprise in the U.S. would be incomplete without a presentation of the statistics of the major chemical parameters over the past 75 years.

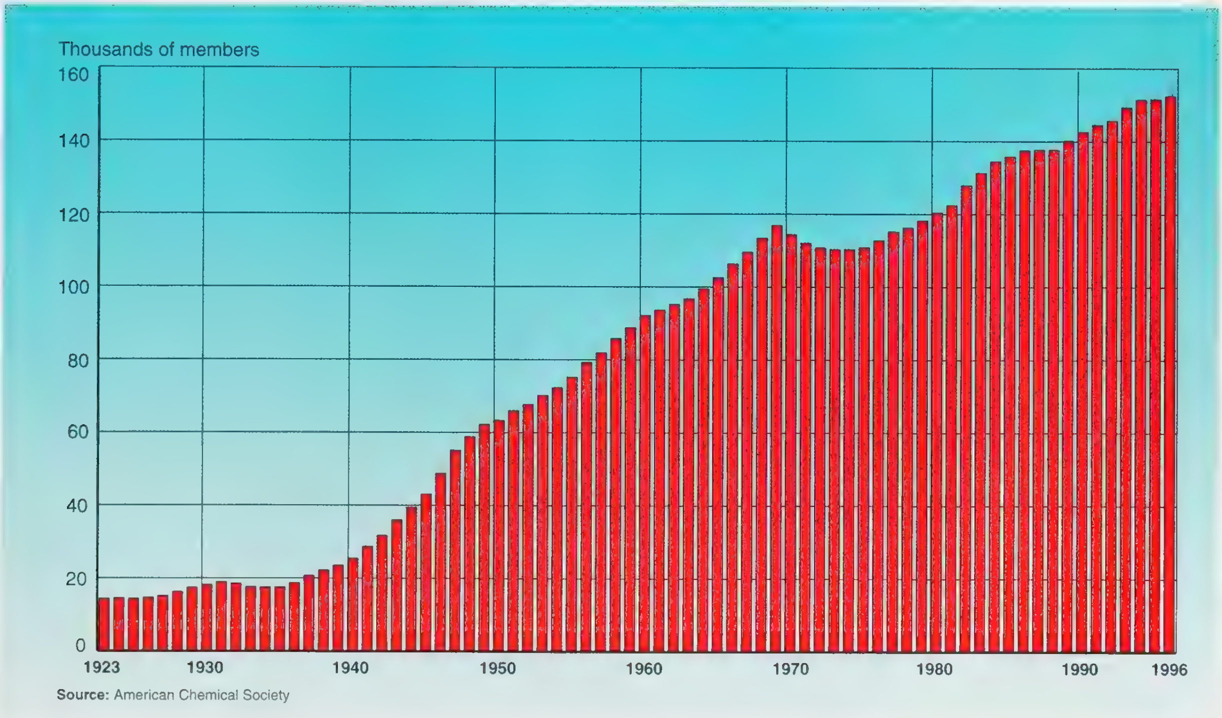
All of the data sets presented here go back at least to the post-World War II period. But many do not go back all the way to 1923. This is for a variety of reasons. For instance, some now very important sectors of the chemical world, such as thermoplastics, did not exist 75 years ago. For some other measures, the level of activity in the early years was so low compared with today's that it cannot be meaningfully presented on a simple graph. For instance, chemical exports were $70 million in 1932. This compares with almost $63 billion in 1996. In other areas, data have not been kept on a consistent basis all the way back to 1923.

Seventy-five years can bring enormous changes in any human activity. For instance, the population of the U.S. was about 110 million in 1923. Today it exceeds 268 million. The cost of living today is about 12 times what it was during the Depression of the 1930s and, in current dollars, the gross national product is 135 times larger.

Even modest rates of growth bring great change when they are sustained. For instance, a steady 2% annual growth rate translates into a 169% gain over 50 years and a 324% gain over 73 years (the latest year for which data are available is 1996). With a 3% growth rate, these long-term gains balloon to 338% and 765%, respectively.

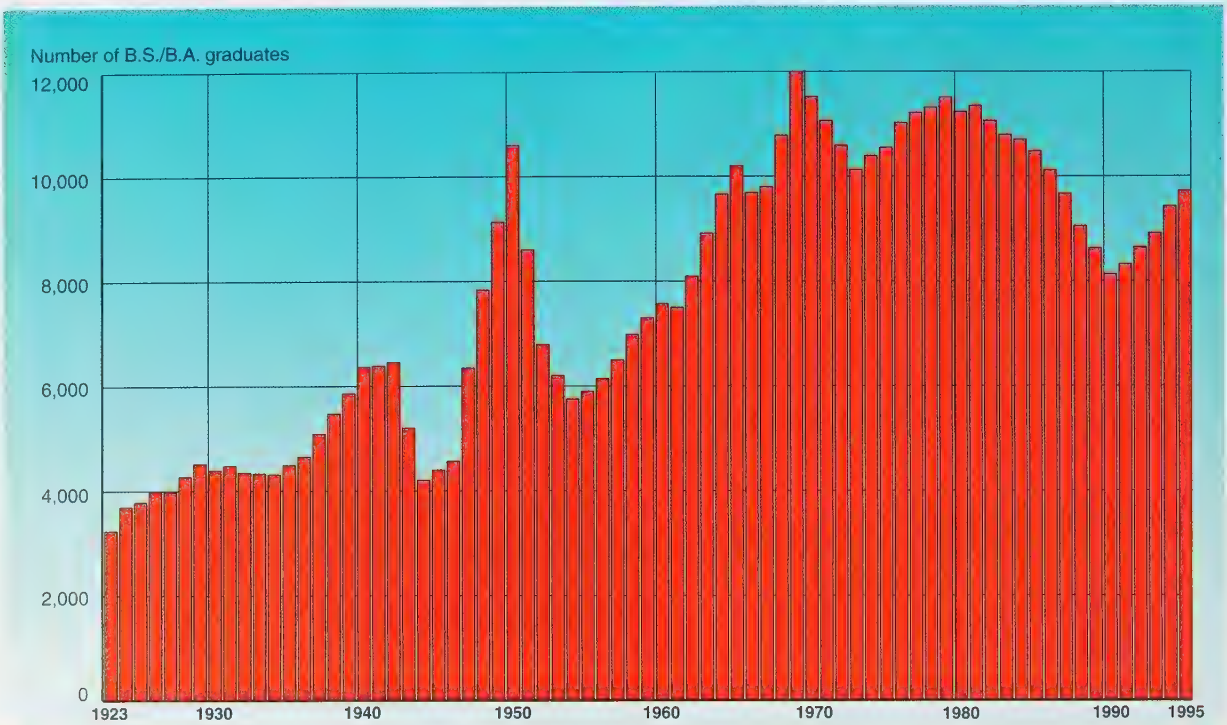
All of the data presented are consistent with a chemical enterprise that has grown enormously over the years and that continues to grow. Most of the data are also consistent with the maturity that eventually comes to any enormous activity—with a peaking of growth coming roughly 20 years ago and with slower, more halting, but probably more sustainable, growth since.◀

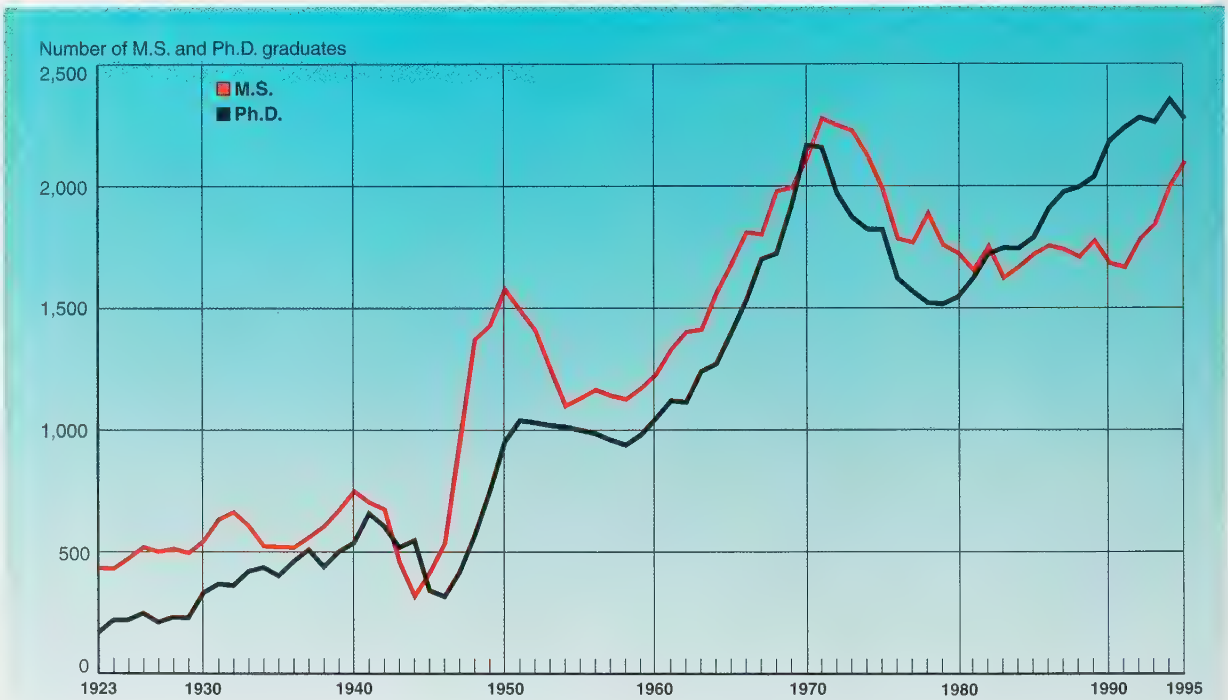
AMERICAN CHEMICAL SOCIETY MEMBERSHIP: Solid growth faltered only during Depression of 1930s and recession of early 1970s



ACS membership has grown at an average annual rate of 3.2% since 1923. Growth was strongest from the later years of the Depression through the early post-World War II years, with an average 9.2% annual gain from 1935 through 1951. The longest pause in growth came in the 1970s. Membership dropped from nearly 117,000 in 1969 to about 110,000 between 1972 and 1975 and did not move ahead of the 1969 level until 1979.

CHEMISTRY GRADUATES: Strong growth in annual number of graduates through 1970, no further gains since then

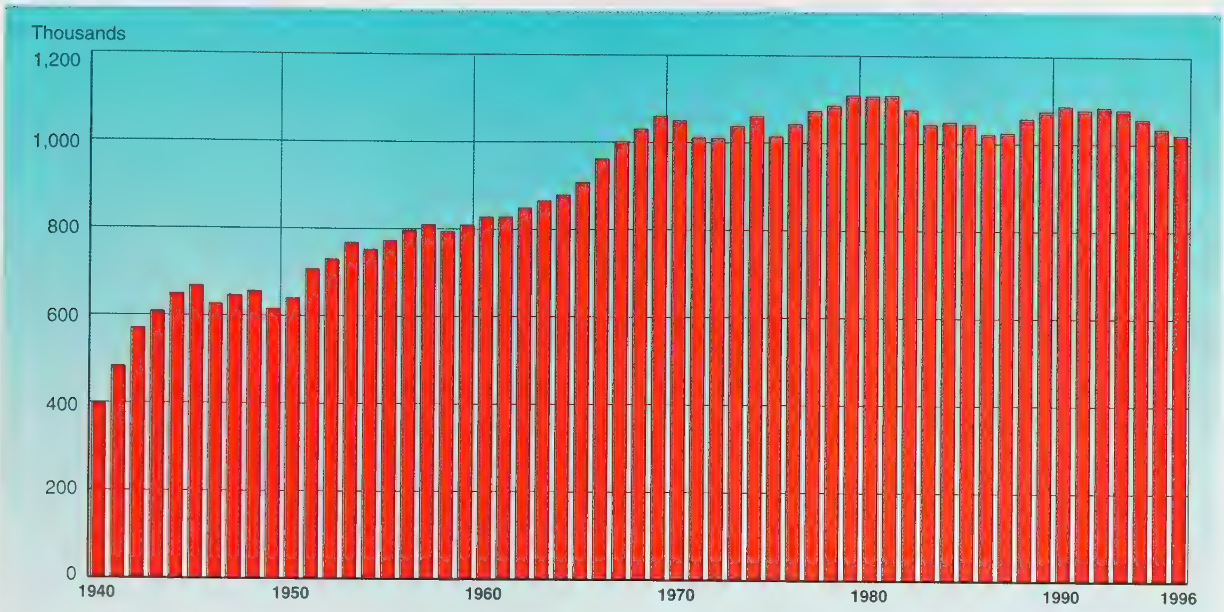




Sources: Department of Education; American Chemical Society; Chemistry in America 1876–1976

The number of graduates with chemistry bachelor's degrees held up quite well during the Depression (1930s), dipped during World War II (1941–45), and surged in its immediate aftermath. The number of graduates then moved up to a high in the late 1960s, fluctuated, and hit a low in 1990. Since then, the numbers have increased steadily. Master's and doctorates show similar patterns, with current levels at, or near, highs set in the early 1970s.

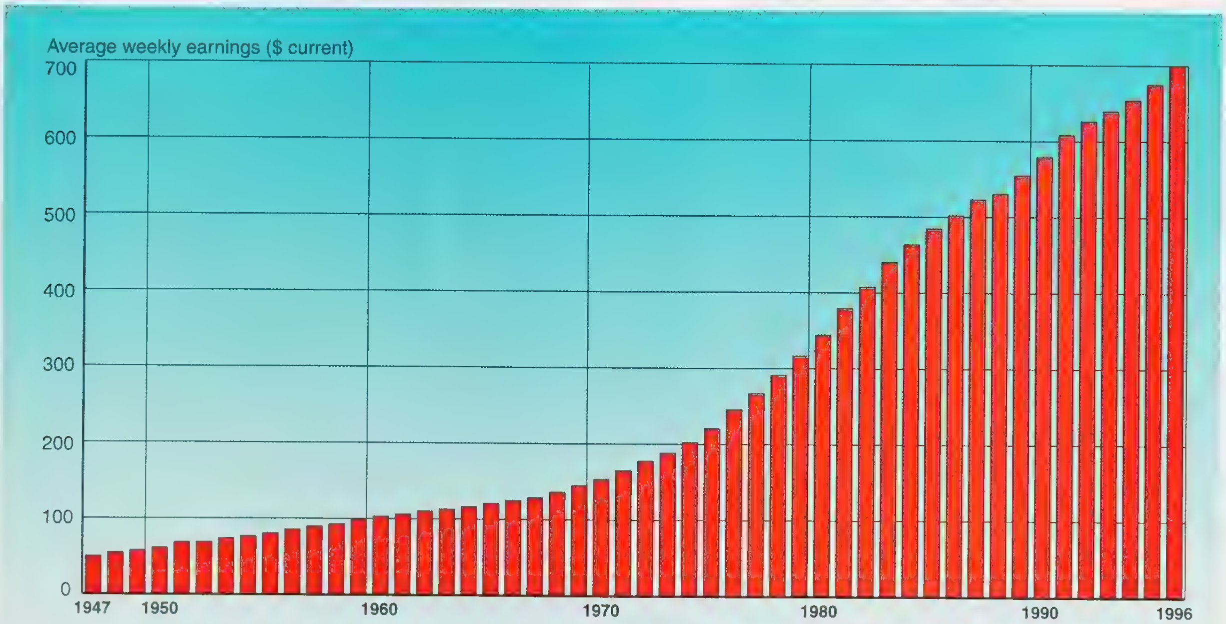
CHEMICAL INDUSTRY EMPLOYMENT: Has held at over 1 million for past 30 years



Note: Average annual domestic employment in U.S. chemicals and allied products industry. **Source:** Department of Labor

Employment in the chemicals and allied products industry surged in the 1940s in response to the end of the Depression and the demands of World War II. It first reached 1 million in 1967 and has held above this level ever since, reaching a peak of 1,109,300 in 1979. However, employment has been declining since 1991 to an average of 1,020,000 in 1996.

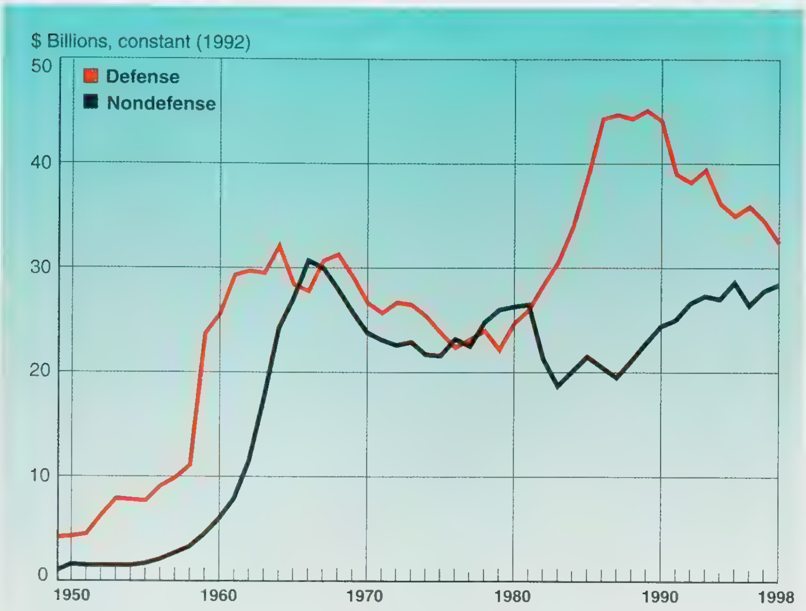
WAGES: Chemical production worker earnings have averaged 5.5% annual gain for past 50 years



Note: Earnings for production workers in U.S. chemicals and allied products industry. **Source:** Department of Labor

The weekly earnings of production workers in the chemicals and allied products industry have grown from $50 in 1947 to $700 in 1996. This represents an average annual gain of 5.5%. Growth has been uninterrupted, with no year-to-year declines. The average annual increase in the Consumer Price Index over this period has been 4.1%.

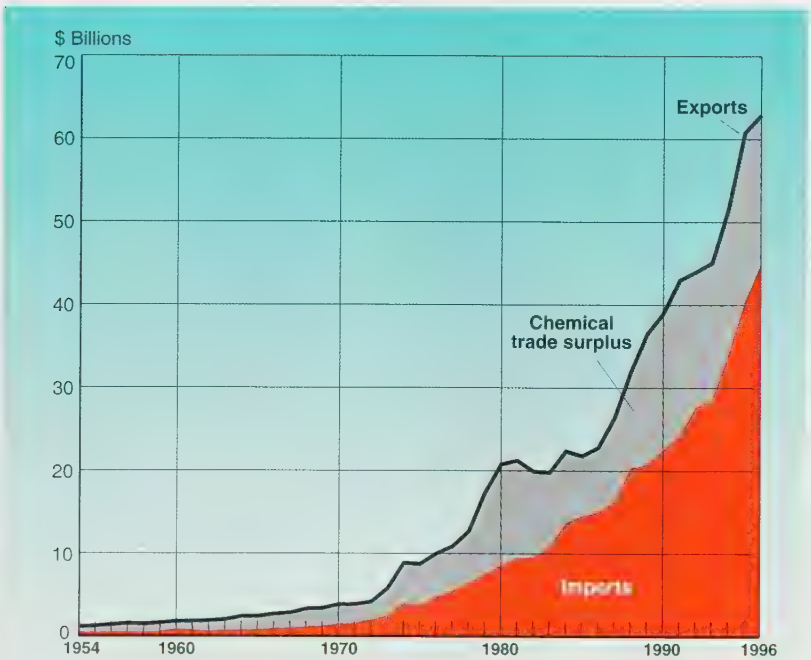
FEDERAL R&D OUTLAYS: Defense R&D down, but still above Cold War levels; nondefense in $20 billion to $30 billion range for past 30 years



Note: Data for 1997 and 1998 are estimates. **Source:** Office of Management & Budget

Federal R&D spending has increased, in current-dollar terms, from $940 million in 1949 to $70 billion for fiscal 1998–an average annual growth rate of 9.2%. In constant 1992 dollars, the gain has been from $5.2 billion to $60.7 billion, with a high of $68.5 billion in 1990. Since 1987, nondefense R&D has risen, in constant dollars, from $19.5 billion to $28.4 billion, and defense R&D has fallen from $44.7 billion to $32.4 billion.

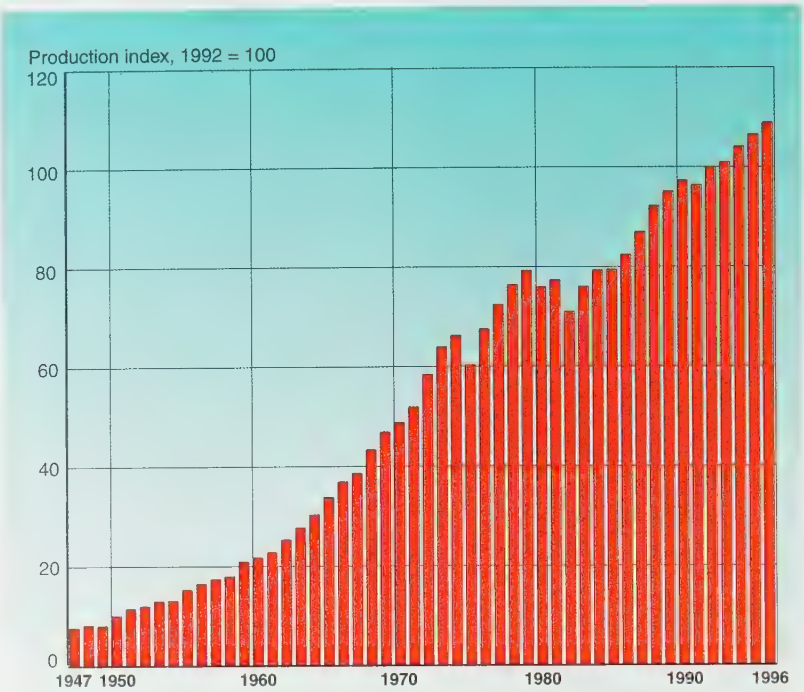
CHEMICAL TRADE: Value of chemical exports and of chemical trade surplus have both grown about 50-fold since 1950s



Source: Department of Commerce

The chemical industry has enjoyed a trade surplus since the 1920s. Growth has been spectacular since 1954 when chemical exports first reached $1 billion with a surplus of $700 million. In 1996, chemical exports exceeded $60 billion per year with an $18 billion surplus. This growth has come during a time when the U.S.'s overall trade balance has eroded from a $2.5 billion surplus in 1954 to a deficit of $167 billion in 1996. The chemical industry's surplus is the largest for any major trade category.

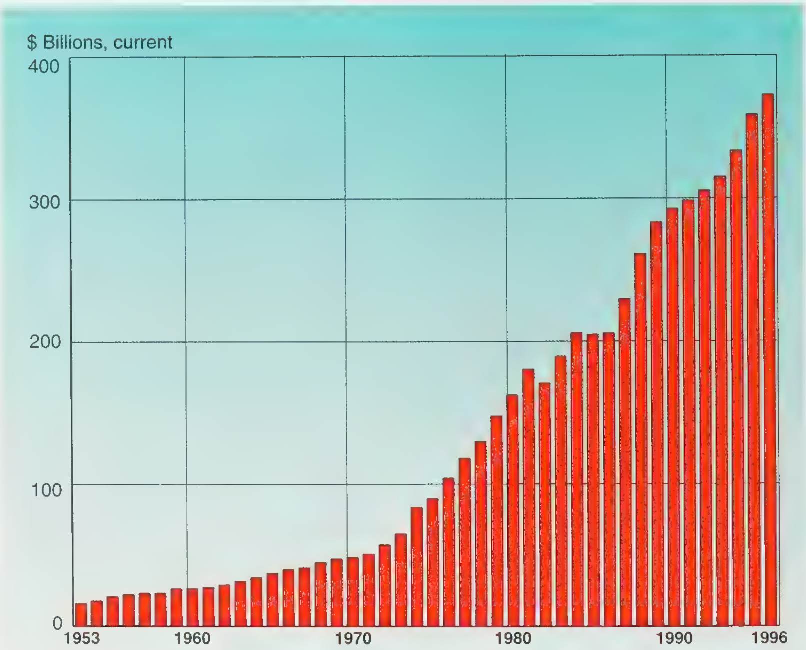
CHEMICAL PRODUCTION: Annual gain has dropped from 8.3% for 30 years following World War II to 2.3% for past 20 years



Note: Production in U.S. chemicals and allied products industry. Source: Federal Reserve Board

Production of chemicals and allied products has grown at an average annual rate of 5.6% since just after World War II. The only major pause in the upward trend came during the deep recession of the early 1980s. Partly as a result of this, the rate of growth has changed dramatically, from an average 8.3% during the 1970s to 2.3% since the early 1980s. For the past 10 years, it has been 2.8%.

CHEMICAL SHIPMENTS: Have averaged 7.5% annual growth rate for past 40 years



Source: Department of Commerce

Fastest growth in value of shipments of chemicals and allied products came in the 1970s–an average annual growth of almost 14%. Shipments have grown 6% per year for the past 10 years. Today, chemical shipments represent 10% of total shipments from all manufacturing industries. This is up from 6% during the 1950s.

CHEMICAL PRODUCERS: Dow Chemical, DuPont, Monsanto, and Union Carbide have ranked among Top 10 biggest chemical makers since 1940

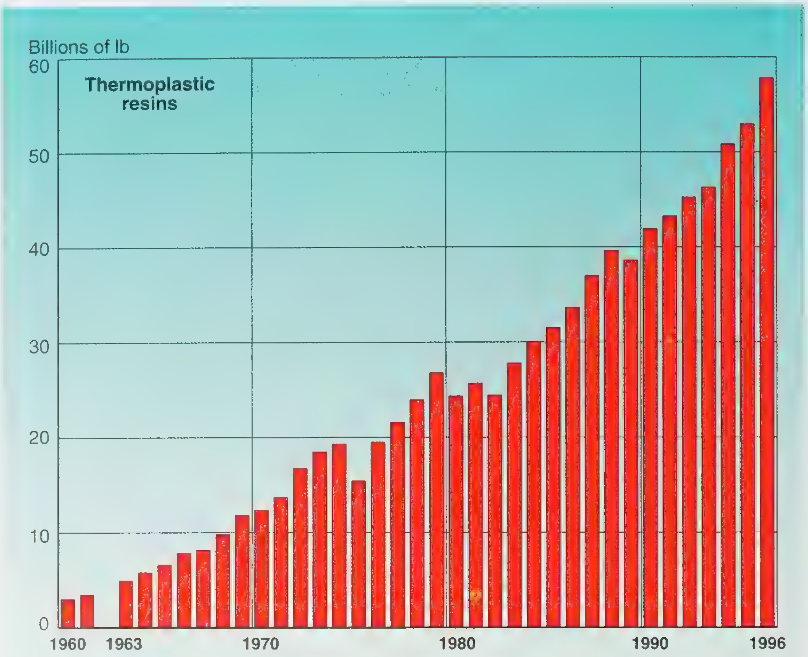
Company rankings by sales, $ millions (current)

	1	2	3	4	5	6	7	8	9	10
1940	DuPont $359	Union Carbide & Carbon $231	Allied Chemical & Dye $177	American Cyanamid $88	American Viscose $63	Hercules Powder $52	Monsanto $51	Celanese $46	Dow Chemical $38	Air Reduction $36
1945	DuPont $632	Union Carbide & Carbon $482	Allied Chemical & Dye $268	American Cyanamid $159	Dow Chemical $125	American Viscose $119	Celanese $104	Hercules Powder $101	Monsanto $95	Air Reduction $81
1950	DuPont $1,310	Union Carbide $758	Allied Chemical & Dye $408	American Cyanamid $322	American Viscose $268	Celanese $233	Monsanto $227	Dow Chemical $221	Hercules Powder $160	Air Reduction $98
1955	DuPont $1,909	Union Carbide $1,187	Allied Chemical & Dye $629	Olin Mathieson $561	Monsanto $522	Dow Chemical $471	American Cyanamid $451	W.R. Grace $427	American Viscose $259	Hercules Powder $227
1960	DuPont $2,143	Union Carbide $1,548	Monsanto $890	Dow Chemical $781	Allied Chemical $766	Olin Mathieson $668	American Cyanamid $578	W.R. Grace $553	Hercules $337	Celanese $264
1965	DuPont $2,999	Union Carbide $2,064	Monsanto $1,468	Dow Chemical $1,176	Allied Chemical $1,121	W.R. Grace $1,003	Olin Mathieson $874	American Cyanamid $863	Celanese $862	Hercules $532
1970	DuPont $3,224	Union Carbide $1,876	Monsanto $1,716	Dow Chemical $1,643	Standard Oil (N.J.) $1,007	Celanese $999	W.R. Grace $894	Allied Chemical $837	Hercules $687	Occidental Petroleum $658
1975	DuPont $5,500	Union Carbide $3,425	Dow Chemical $3,360	Monsanto $3,054	Exxon $2,594	W.R. Grace $1,800	Celanese $1,716	Allied Chemical $1,522	Occidental Petroleum $1,447	Shell Oil $1,203
1980	DuPont $10,250	Dow Chemical $7,217	Exxon $6,936	Union Carbide $5,650	Monsanto $5,453	Celanese $3,200	Shell Oil $3,089	W.R. Grace $2,733	Gulf Oil $2,569	Occidental Petroleum $2,458
1985	DuPont $11,250	Dow Chemical $9,508	Exxon $6,670	Monsanto $5,203	Union Carbide $3,961	Atlantic Richfield $3,804	Shell Oil $3,318	Celanese $3,046	Amoco $2,905	W.R. Grace $2,868
1990	DuPont $15,571	Dow Chemical $14,690	Exxon $11,153	Union Carbide $7,621	Monsanto $5,711	Hoechst Celanese $5,499	General Electric $5,167	Occidental Petroleum $5,040	BASF $4,366	Amoco $4,087
1995	Dow Chemical $19,234	DuPont $18,433	Exxon $11,737	Hoechst Celanese $7,395	Monsanto $7,251	General Electric $6,628	Mobil $6,155	Union Carbide $5,888	Amoco $5,655	Occidental Petroleum $5,410
1996	Dow Chemical $18,988	DuPont $18,044	Exxon $11,430	Monsanto $7,267	Hoechst Celanese $6,906	General Electric $6,487	Union Carbide $6,106	Amoco $5,698	Eastman Chemical $4,782	BASF Corp. $4,707

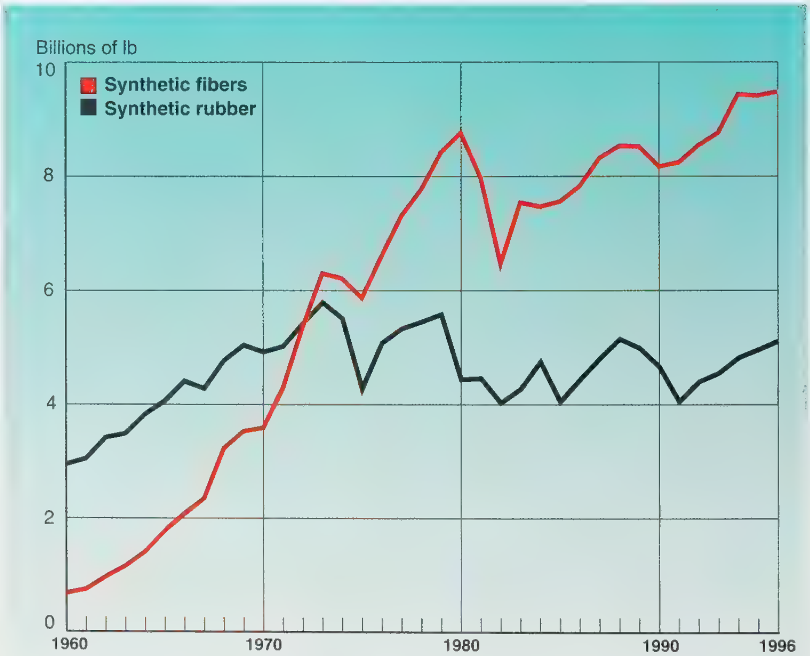
Note: Ranking based on total corporate sales through 1965, and on chemical sales only since 1970

The combined chemical sales of the 10 largest U.S.-based chemical producers have grown from about $1 billion in 1940 to just over $90 billion in 1996. Expansion of the industry is shown by the appearance of oil companies on the Top 10 list in the 1970s and of the U.S. arms of major foreign chemical makers in more recent years. Dow Chemical finally overtook DuPont for the number one spot in 1995. Union Carbide, for a long time the number two producer, has moved down the ranking as a result of various reorganizations. Monsanto will fall in the ranking in 1997—perhaps out of the Top 10—as a result of spinning off much of its chemical operations into a new firm, Solutia.

POLYMERS: Strong growth continues for thermoplastic resins, slow growth for synthetic fibers, and no growth for synthetic rubber during past 20 years



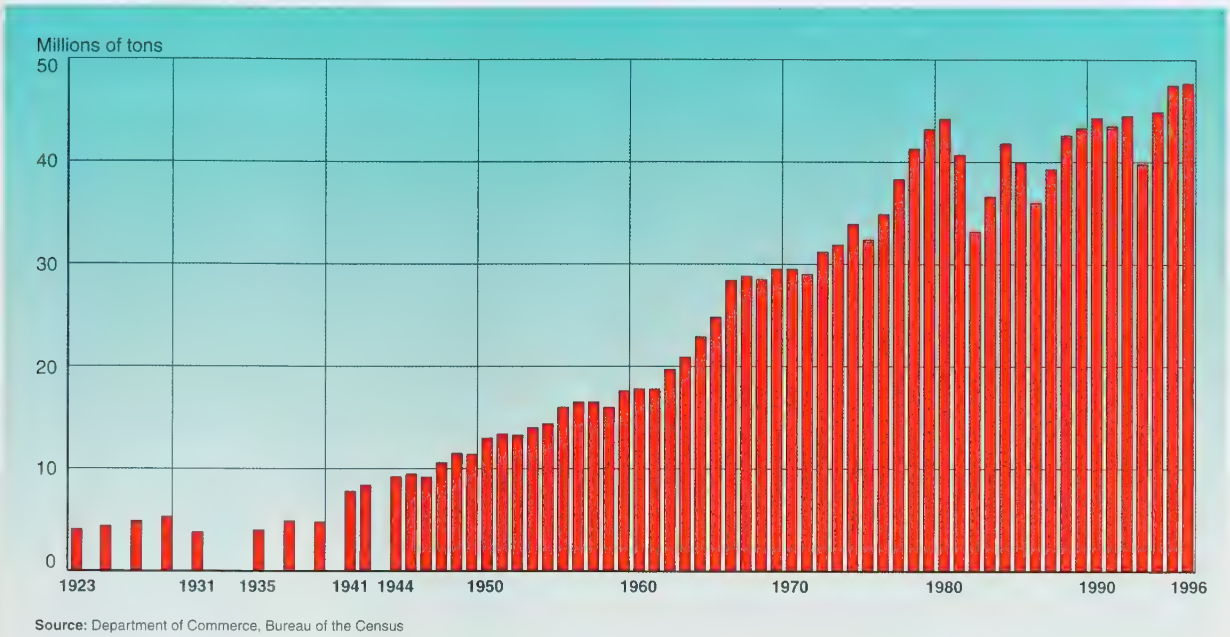
Note: Includes low-density polyethylene, high-density polyethylene, polypropylene, polystyrene, and polyvinyl chloride.
Sources: International Trade Commission and Society of the Plastics Industry



Sources: Rubber: Department of Commerce and Rubber Manufacturers Association; Fibers: Fiber Economics Bureau

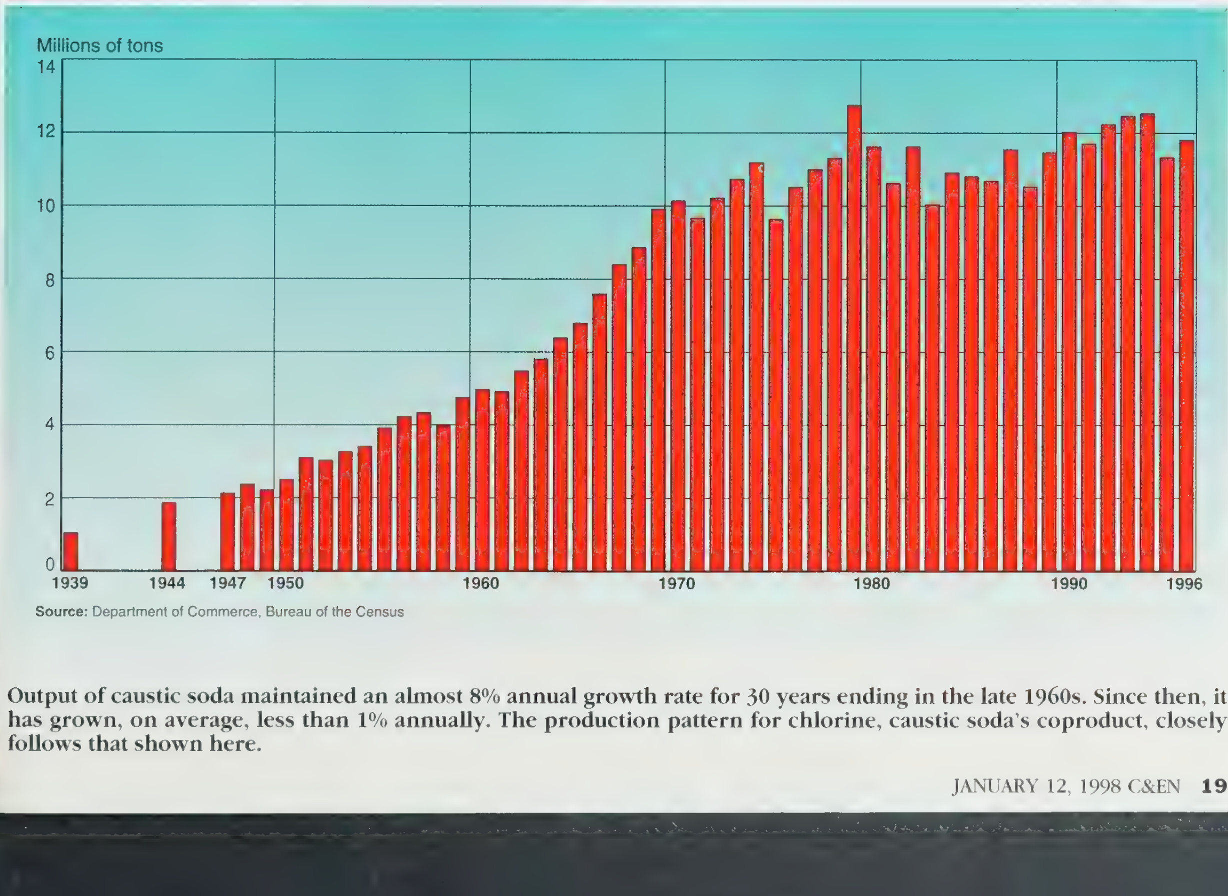
Production growth of thermoplastic resins in this country has averaged 8.6% from 1960 until the present. Partly due to the small starting bases, the growth rate was 12.2% for the first 18 years of this period. For the second 18 years, it was still a healthy 5.0%. Synthetic (noncellulosic) fibers grew even faster between 1960 and 1978–at an average rate of 14.5% annually. Since then, synthetic fibers have grown at a 1.4% rate. Synthetic rubber production has been pretty flat for the past 20 years.

SULFURIC ACID: Output of largest volume commodity chemical has averaged 3.4% annual growth since 1923



Production of sulfuric acid boasted almost uninterrupted growth until the early 1980s when it dipped by 25% within two years. Since then, it has posted a 2.8% annual growth rate to move into new high ground.

CAUSTIC SODA: Strong growth until 20 years ago, production flat since



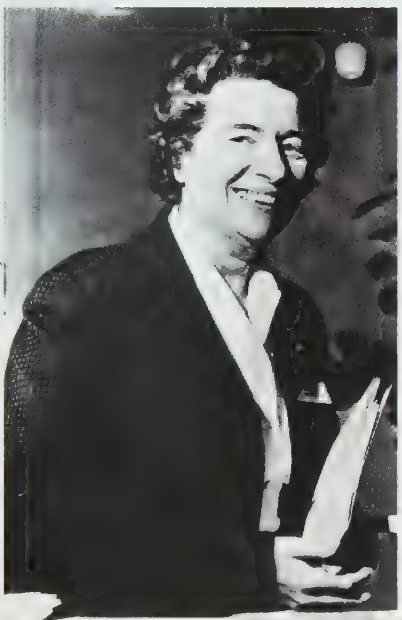
Output of caustic soda maintained an almost 8% annual growth rate for 30 years ending in the late 1960s. Since then, it has grown, on average, less than 1% annually. The production pattern for chlorine, caustic soda's coproduct, closely follows that shown here.

The Periodic Table—1923 & 1998

Periodic table's size and shape have changed since 1923

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Ti	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	110	111	112						
			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
		Actinide series	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Nearly one-fourth (23%) of all the known elements (those in color) have been added to the periodic table since 1923, including all 20 that have atomic numbers greater than that of uranium, element 92. Most of the new elements (those in red) were first created synthetically through nuclear reactions, although several of these elements were later found to be naturally occurring as well. A new row, representing the actinide series, was added to the periodic table in 1945. Elements in color with atomic numbers smaller than that of uranium were assumed to exist but were undiscovered in 1923; those in blue were discovered by isolation from natural sources.



Courtesy of J.-P. Adloff and G. B. Kauffman

Marguerite Perey isolated francium from uranium ore.

Rebecca L. Rawls
C&EN Washington

The past 75 years have been some of the richest ever for the discovery of new elements. Since C&EN began publication in 1923, 26 elements have been added to the periodic table. On average, that's about one new element every three years.

The era spans a major change in the kind of elements being discovered. Hafnium (discovered in 1923) and rhenium (in 1925) were the last elements with stable nuclei to be added to the periodic table. Beginning with technetium, discovered in 1937, the new elements are radioactive in all of their isotopes. All but one of them were "discovered" shortly after they were artificially produced through nuclear transmutation reactions, although some, such as neptunium and plutonium, were later found also to occur in nature.

With the discovery of hafnium, element 72, the then-new field of atomic physics was becoming crucial to the discovery of new elements. Although not a rare element, hafnium was nearly impossible to distinguish chemically from the much more common element zirconium. Dutch physicist Dirk Coster and Hungarian chemist George Karl von Hevesy used Neils Bohr's theory of how electrons fill shells and subshells within atoms to predict differences in the two elements' X-ray spectra. They then demonstrated that they could detect X-rays from both elements in a sample of a zirconium-rich ore. They named the element after Bohr's hometown of Copenhagen (Hafnia in Latin).

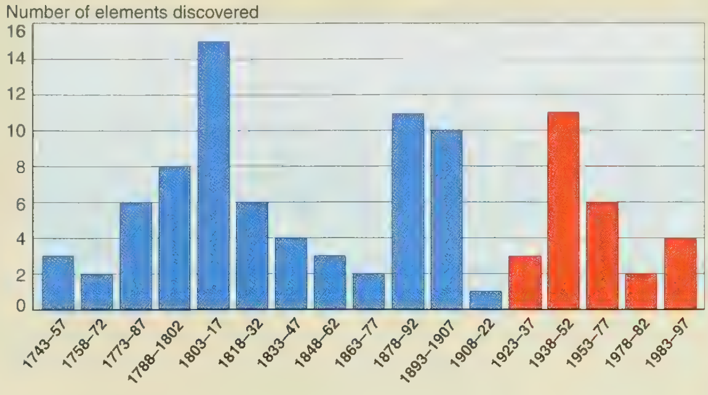
The last element to be discovered in nature was francium, element 87, whose longest lived isotope has a half-life of only 22 minutes. That isotope, produced during the natural decay of uranium-235, was chemically separated from uranium ore by Marguerite Perey at the Curie Laboratory in Paris in 1939.

By the mid-1930s, spurred by the discovery of the neutron in 1932 and artificial radioactivity in 1934, nuclear scientists—some trained as chemists, others as physi-

cists—were attempting to bombard heavy elements like uranium with neutrons in the hope of synthesizing new elements. Italian physicist Enrico Fermi and colleagues tried to do so in 1934 and thought they had succeeded. But four years later, Otto Hahn and Fritz Strassmann demonstrated experimentally that Fermi had instead discovered a new nuclear reaction, later named fission.

Nuclear particles are more likely to "stick" to a target nucleus if they are moving at high speed, something that became technically feasible in 1929 when Ernest O. Lawrence invented a circular accelerator for charged particles called a cyclotron. Construction of the first of these accelerators on the Berkeley campus of the University of California in 1931 set the stage for the synthesis of new elements. The first, technetium—the name means artificial in Greek—was produced at Berkeley in 1937 by bombarding molybdenum with deuterium nuclei (deuterons) and was identified in Italy by Emilio Segrè and Carlo Perrier. That was quickly followed by astatine, produced and identified in 1940 from the bombardment of bismuth with helium nuclei.

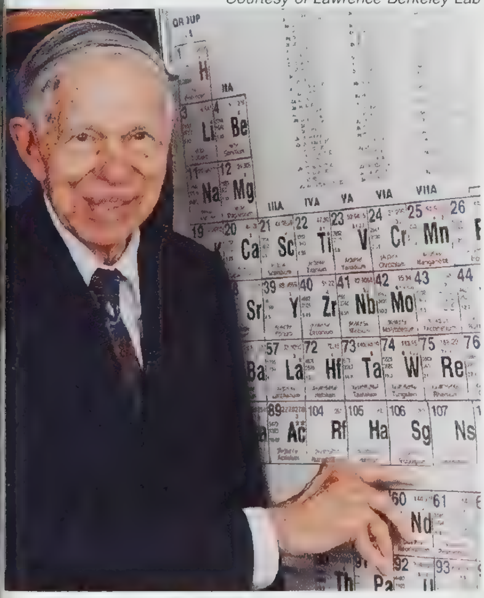
Number of elements keeps growing



The period since 1923 has been one of the most productive for the discovery of new elements. Bars represent the number of elements discovered during consecutive 15-year periods since the systematic search for chemicals began in the mid-18th century. Twenty-six elements have been added in the past 75 years—a rate of about one every three years. The most recent, the as-yet-unnamed element 112, was discovered in 1996.

Efforts to produce a transuranium element—one with a nucleus heavier than that of uranium, element 92—finally succeeded in 1940 when Edwin M. McMillan and Philip H. Abelson bombarded uranium with neutrons to produce neptunium, element 93. A follow-on series of experiments bombarded uranium with deuterons to produce a heavier isotope of neptunium, which decayed by β-emission to element 94, plutonium, identified by Glenn T. Seaborg, Arthur C. Wahl, and Joseph Kennedy in 1941.

Courtesy of Lawrence Berkeley Lab



lenn T. Seaborg points to element 106, amed seaborgium in his honor.

Over the next three decades, the Berkeley researchers (relocated to the University of Chicago during much of World War II) produced and identified nine more transuranium elements. And three other new elements were identified during the development of nuclear weapons. Of these, promethium (element 61), a fission product of uranium, was identified in 1945 as part of the wartime plutonium production project at Oak Ridge, Tenn. Einsteinium and fermium (elements 99 and 100, respectively) were discovered in the debris from the test of the first hydrogen bomb in 1952 by researchers at Los Alamos National Laboratory. The fermium isotope discovered after this blast had been created by 17 successive neutron captures in uranium, followed by sequential β-decay.

One of the very few pieces of original research ever published in C&EN was Seaborg's proposal in 1945 that the elements heavier than actinium had been misplaced in the periodic table, where they had been located as transition-series metals. On the basis of the chemical properties of neptunium, plutonium, and the two elements that follow them—americium and curium—Seaborg proposed a second lanthanide-like series, which he named the actinide series.

Since the mid-1970s, synthesis of ever-heavier new elements has depended on new generations of particle accelerators. Three facilities have been the major centers for this work—the Joint Institute for Nuclear Research in Dubna, Russia; the heavy ion research facility in Darmstadt, Germany, known as GSI; and Lawrence Berkeley National Laboratory. Elements produced in experiments at these facilities have half-lives that range from seconds to milliseconds and sometimes are produced in quantities of fewer than 100 atoms. What constitutes positive identification of a new element in such circumstances has become an increasingly important question. The International Union of Pure & Applied Chemistry (IUPAC), which has final say on the names of elements, has become, in effect, the arbitrator in a number of disputes over first discovery.

Last August, IUPAC gave its endorsement to a compromise slate of names for elements 101 to 109. Some of the proposed names had been embroiled in considerable controversy, and IUPAC sought to spread the credit for element discovery. Thus, element 105 was named dubnium to acknowledge the many contributions of the Russian lab. The Berkeley group got two of the names it wanted—rutherfordium for 104 and seaborgium for 106. And the GSI group, headed by Peter J. Armbruster, got credit for discovering elements 107, 108, and 109 with the names bohrium, hassium, and meitnerium, respectively. Between 1994 and 1996, the GSI group claimed discovery of three more elements—110, 111, and 112—none of which has been named yet.◀

AMERICAN CHEMICAL SOCIETY
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Inclusive Dates/Employment (MO./YR.) ____________________

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Time Spent on Chemical Work ____________________%

Work Functions ____________________

____

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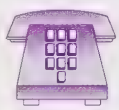

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Phone: 1-800-333-9511 (in the US) or 614-447-3776
Fax: 614-447-3671 • **E-mail:** service@acs.org
Web: http://pubs.acs.org

IUPAC AFFILIATION

❑ **IUPAC Affiliation $29.00** (U.S. members only). The International Union of Pure and Applied Chemistry (IUPAC) offers individual affiliation to members of national chemical societies. Recognized by all the sciences and by the national level academies of science as the international representative body for chemistry, IUPAC is the authority on chemical nomenclature, terminology, symbols, atomic weights, and related topics. IUPAC Affiliates dues for ACS members residing in the U.S. are $29.00 and include a subscription to *Chemistry International* magazine.

NOMINATION

Nomination by two ACS members is required by ACS Bylaws. If this presents difficulty, please call the Admissions Office at (202) 872-4568 for assistance. NOTE: Such nomination is not necessary for former members. Student affiliation does not constitute membership.

We recommend for membership in the American Chemical Society:

Name of Applicant

ACS Member: ____________________
Signature

Printed Name

ACS Member: ____________________
Signature

Printed Name

AGREEMENT

I attest to the accuracy of information on the 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 before January 1 of the year for which my resignation is to take effect.

Signature of Applicant

Date

The mission of the American Chemical Society is to encourage in the broadest and most liberal manner the advancement of the chemical enterprise and its practitioners.

Advertising Rate Information

CLASSIFICATIONS

Positions open—placement bureaus, industrial positions, and academic positions. Situations wanted—members, nonmembers, student and national affiliates, retired members.

Issuance: Published weekly, issued every Monday. Mailed Friday preceding date of issue.

Closing Date for Classified Ads: Standard Set Ads—Thursday, 10 a.m. 18 days preceding publication date. Display—Ads—Friday, 10 a.m. 17 days preceding publication date. No extensions. Cancellations must be received 14 days in advance of publication date (except legal holidays.)

ACS MEMBER RATES

"Situations Wanted" advertisements will be classified by the chemical field designated by the members. If not designated, placement will be determined by the first word of the text submitted.

EMPLOYED MEMBERS

"Situations Wanted" advertisements placed by employed ACS members and affiliates are accepted at $6.60 a line per insertion, no minimum charge. State ACS membership status and mail advertisements to: Chemical & Engineering News, Classified Advertising, 676 East Swedesford Road, Suite 202, Wayne, PA 19087-1612. Phone: (610) 964-8061; Fax: (610) 964-8071.

UNEMPLOYED & RETIRED MEMBERS

Unemployed members and affiliates, members and affiliates under notice of involuntary unemployment within 60 days, and student members and affiliates who have not found employment two months prior to graduation may place **free** advertisements (up to 35 words) in C&EN on a biweekly basis (maximum 18 insertions each calendar year). Retired members who are looking for part-time employment, and who have applied for retired status with ACS may place **free advertisements** (up to 35 words) in C&EN on a monthly basis (maximum 6 insertions each calendar year). The "Consultant Section" is reserved for retired members only.

To place an ad: Advertisers must include their name, address, daytime telephone number, ACS membership number, and details of their unemployment upon submitting a request. A box number will be assigned; however, if confidentiality is not a factor, use a direct-mail address and/or phone or fax number for a quicker response. Send copy for free ads to American Chemical Society, Department of Career Services, 1155—16th St., N.W., Washington, DC 20036; fax (202) 872-4529. Copy will not be accepted by phone. All requests will be confirmed via mail. For more information, call (800) 227-5558, press 9, 3, 1.

EMPLOYER AND NONMEMBER AD PLACEMENT

RATES: Non-Display (Standard Set) Ads are $49 net per line; $490 minimum. One line equals approximately 52 characters and spaces, centered headlines equal approximately 32 characters, bold caps, and spaces; all in 7-point type.

Display Ads are $520 per column inch; sold by the column inch only. For rates and information on display ads over 4 inches call Matt McCloskey at (610) 964-8061.

Internet Ads: All classified advertisements are automatically posted on the ACS Job Bank. If you want your ad to appear only on the INTERNET and not in the weekly printed edition of C&EN, please call Matt McCloskey for rates at (610) 964-8061.

TO SUBMIT A CLASSIFIED AD: Simply send us double-spaced, typewritten copy. Do not include any abbreviations. C&EN will typeset ads according to ACS guidelines. All ads must be accompanied by a Purchase order number and a billing address. Mail or fax advertisements to Chemical & Engineering News, Classified Advertising, 676 East Swedesford Road, Suite 202, Wayne, PA 19087-1612. Phone (610) 964-8061; Fax: (610) 964-8071.

CONDITIONS

In printing these advertisements ACS assumes no obligations as to qualifications of prospective employees or responsibility of employers, nor shall ACS obtain information concerning positions advertised or those seeking employment. Replies to announcements should carry copies of supporting documents, not original documents. Every reasonable effort will be made to prevent forwarding of advertising circulars. Employers who require applications on company forms should send duplicate copies. ACS considers all users of this section obligated to acknowledge all replies to their advertisements.

IMPORTANT NOTICES

- Upon request, the Office of Professional Services provides copies of Professional Employment Guidelines and furnishes information on terminations of chemical professionals.
- Employment in countries other than your own may be restricted by government visa and other policies. Moreover, you should investigate thoroughly the generally accepted employment practices, the cultural conditions, and the exact provisions of the specific position being considered. Members may wish to contact the ACS Awards and International Activities Department for information it might have about employment conditions and cultural and cultural practices in other countries.
- Various state and national laws against discrimination, including the Federal Civil Rights Act of 1964, prohibit discrimination in employment because of race, color, religion, national origin, age, sex, physical handicap, sexual orientation or any reason not based on a bona fide occupational qualification.
- These help wanted and situations wanted advertisements are for readers' convenience and are not to be construed as instruments leading to unlawful discrimination.
- Position descriptions shall conform to the official ACS definition of a chemist which is available through the Office of Professional Services. Employers whose advertisements appear have been informed that position descriptions must conform to this definition.

ACS Career Services

The ACS Department of Career Services is pleased to serve our members by providing career assistance and programs for professional development. The Professional Data Bank (PDB) provides employers with information on scientific professionals seeking employment. The PDB is designed to match employers' specifications with our registered members' qualifications. The PDB is **not** confidential, operates on a year-round basis, and is free to ACS members and student and national affiliates. The Department of Career Services also has a Confidential Employment Listing Service (CEL) available to our members who wish to have their confidentiality assured, but who wish to be included in the PDB. The cost for the CEL is $40 per year. For the necessary forms for the PDB or CEL, or for information on programs and publications sponsored by the Department of Career Services, please call (800) 227-5558 (9,3,1) or e-mail: career@acs.org. For a fee, **employers** can access the more than 5,000 scientific professionals included in the PDB. Interested employers should contact ACS at (202) 872-6213.

POSITIONS OPEN

INDUSTRIAL POSITIONS

WINK ENGINEERING

Consulting Engineering Firm Servicing Petrochemical/Refining/Offshore Industries. Process/Chemical Engr - 3+ yrs Refinery Exp (Positions in New Orleans area). Process/Chemical Engr - 7+ yrs Offshore Exp (Positions in New Orleans & Lafayette areas). **504/243-4532 800/245-8274 E-Mail RESUME@WINKINC.COM Pat Stansbury**

ORGANIC CHEMIST

MAXIA Pharmaceuticals, Inc., a biopharmaceutical company, is seeking an organic synthetic chemist with a strong background in analytical chemistry to establish and perform pharmacokinetic analysis on innovative retinoid molecules. The candidate will have 1-4 years of postdoctoral experience in organic analytical chemistry in an academic or industrial setting. MAXIA offers a competitive compensation and comprehensive benefits package. Please send CV to **W. Lernhardt Ph.D. #CH981, MAXIA Pharmaceuticals, Inc., 10835 Altman Row, San Diego, CA 92121.**

CHEMICAL/PHYSICAL SPECTROSCOPIST

The Analytical Chemistry Division of the National Institute of Standards and Technology (NIST) is seeking a research chemist or physicist to fill a term position (2 year) making high accuracy optical measurements as well as spectroscopic and spectrophotometric determinations. The candidate must have skill in applying physical, mathematical, and computing principles to the design and fabrication of light-measuring devices. The researcher will develop and certify standards used to validate the performance of analytical chemistry instrumentation and to assure national traceability and international comparability. Recent research experience is essential. The salary range is $38312 to $60050 depending on qualifications and experience. For specific requirements of the position including how and when to apply, interested applicants must obtain vacancy announcement NIST/97-2407/CAH via the **NIST Vacancy Hotline (301-926-4851)** or via the **WWW (http://www.nist.gov** or **http://www.usajobs.opm.gov).** US citizenship is required, *DOC/NIST is an equal employment/affirmative action employer located in Gaithersburg, MD.*

LABORATORY DIRECTOR - ADHESIVES

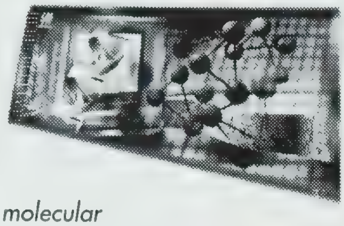
We are a leading manufacturer of water borne adhesives and coatings known throughout the world. Increasing sales have created the need for a Laboratory Director to head our R & D Department. Qualified candidates will have an MS/Phd, at least 3 years experience as a polymer chemist, plus at least 3 years management experience. Background in polyurethanes, epoxy, acrylic and UV - EB curing systems is required as well as knowledge of web laminating processes. Your experience will include a demonstrated ability to work on end user oriented projects, manage lab personnel and take products from the bench to the market place. You will be a self starter requiring little supervision and be able to work on multiple projects at one time. Located in Connecticut we offer a salary commensurate with experience and an unusually generous benefits package. For consideration send a letter, resume and salary history, in confidence, to **Department LDS, Mica Corporation, 80 Lupes Drive, Stratford, CT 06497.** *We are an Equal Opportunity Employer.* Principals only, please.

FERMENTATION SCIENTIST

Condust process optimization expts. for microbial pesticides. Run 1-20L fermentations. B.S./M.S. in chem. engineering, micro. or related field. Send C.V. to **Pam Marrone, President, AgraQuest, Inc. 1105 Kennedy Pl., Davis, CA 95616. agraquest@aol.com**

SPECIALITY CHEMICAL MANUFACTURER

seeks Product Development Chemist - MS organic chemistry with 3 plus years experience in Chemical Manufacturing/Lab Functions or B.S. Organic Chemistry with 6 plus years experience. Must have experience in organic synthesis of speciality or performance chemicals. Desirable N.C. location. Send resume to **Fred Reinecke 405 Battleground Ave., Suite 100, Greensboro NC 27410 (910) 274-4377 Fax (910) 273-0952**



Working on the molecular level to conquer, treat, or prevent debilitating diseases.

DRUG DISCOVERY RESEARCH AT SCHERING-PLOUGH

At the Schering-Plough Research Institute, insightful scientists are discovering innovative therapeutic agents that challenge humankind's most debilitating diseases. If you are seeking an opportunity to be on the cutting edge of exploratory pharmaceutical discovery, become part of an advanced multidisciplinary research group focused on chemical research.

POSTDOCTORAL FELLOW
Structural Chemistry

As a member of the Structural Chemistry Department, you will join a group of scientists working on the development of LC-NMR projects. To qualify, you will need a PhD in Chemistry, Biochemistry or a related area, extensive training in NMR and a demonstrated interest in the application of LC-NMR to different areas of pharmaceutical research. Knowledge of HPLC and Varian NMR equipment is desirable. Strong communication and interpersonal skills are essential.

We offer an excellent compensation package including a competitive salary and comprehensive benefits. For prompt, confidential consideration, we invite you to apply on-line at **http://www.sp-research.com** or send a scannable resume and cover letter, original copy only, referencing Dept. TM74-01-SW, to: Schering-Plough Research Institute, MS #1255, 2015 Galloping Hill Road, Kenilworth, NJ 07033-0539. We are an equal opportunity employer. *We regret we are unable to respond to each resume. Only those selected for an interview will be contacted.*

Schering-Plough Research Institute

Using Science for Human Advantage

To spark a new path of discovery.

At The DuPont Merck Pharmaceutical Company, we blend diverse talents to create an environment focused on applying world-class science to the discovery and development of novel solutions for major unmet medical needs. We devote an extraordinary amount of resources to research and development because we believe life and health can be made better.

BS/MS Chemists

We are seeking BS/MS chemists to synthesize biologically active molecules to support our medicinal chemistry research programs. Individuals will apply state-of-the-art synthetic and purification techniques, as well as NMR and mass spectral methods, to the discovery of potential drugs. The ideal candidates will have completed lecture and laboratory courses in organic chemistry and will have performed undergraduate or graduate research projects. Previous industrial experience is desirable, but not required. Good written and oral communication skills are also desirable.

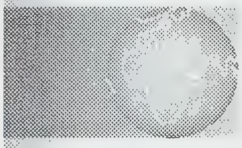
We're a growing company with world class talent and vision. We recognize and reward achievement and distinction at all levels. At DuPont Merck, we believe that individual growth and business success are inseparable. Also, we're located in the Wilmington, DE area, noted for its reasonable cost of living and proximity to major metropolitan areas including Philadelphia, Washington, DC and New York City.

Interested candidates should submit their resumes, along with letters of reference and research summaries to: The DuPont Merck Pharmaceutical Company, P.O. Box 80400, E400/2413, Wilmington, DE 19880-0400. Attn: JR. An equal opportunity employer.

DU PONT
MERCK

The DuPont Merck Pharmaceutical Company
Merging Strengths...Emerging Opportunities.

Your Future in Sight



Alcon Laboratories, Inc., a wholly-owned subsidiary of Nestlé, S.A., is a $2 billion global leader in the research and development of the most complete line of pharmaceutical and medical device products in the ophthalmic and vision care industry. Our primary customers include ophthalmologists and optometrists around the world. We view scientific discovery as the cornerstone of our success. Our focus is innovation in the research and development of pharmaceuticals and medical devices for the preservation and restoration of vision.

In these key positions, the finalists will contribute to the overall success of our R&D and manufacturing efforts as follows:

Principal Scientist
Process Development

- Define robust, cost-effective manufacturing processes for new viscoelastic devices and therapeutic drugs.
- Prepare technical transfer documents required for introduction of manufacturing procedures to Alcon's global manufacturing and clinical supplies facilities.
- Actively contribute to overall project planning and execution of new product introductions to multiple manufacturing environments.
- Provide process and manufacturing information required for regulatory submissions (NDAs, PMAs, IDEs, MAAs, CE Marks, etc.)

Qualifications include a Ph.D. in Pharmaceutics. Chemistry, or Chemical Engineering plus 10 years of applicable work experience. The successful candidate will possess extensive knowledge of synthetic and natural polymer systems (e.g. HA, CS, HPMC) including physical/chemical testing procedures, purification methods, and manufacturing processes as they apply to the pharmaceutical and medical device industry. Knowledge of sterilization techniques and an in-depth understanding of rheological techniques is required. Requirements also include several years of work experience in a sterile manufacturing environment under GMP/GLP conditions; excellent project management and prioritizing skills; and substantial experience with preparing and submitting regulatory documents. **(Code: PSPD)**

Senior Scientist
Product Support

- Develop improvements to products and processes which are cost effective and can be adapted to a manufacturing scale.
- Problem solve for manufacturing and QA.
- Prepare stability lots to support the introduction of new packaging components, vendor qualifications, process qualifications, or the use of technical equipment.
- Prepare process and manufacturing documentation necessary for support of government submissions.

Qualifications include a Ph.D. in Pharmaceutics, Chemistry, or Chemical Engineering plus 7 years of applicable work experience; or, an M.S. plus 10 years. Work experience should include employment in a sterile manufacturing facility under GMP conditions. The successful candidate will possess extensive knowledge of process development and manufacturing techniques including sterilization, filtration, ballmilling, and process scale-up. **(Code: SSPS)**

Alcon Laboratories' professionals enjoy a state-of-the-art environment, along with industry-competitive salaries and excellent benefits, including medical/life/dental/vision insurance and a very generous profit sharing trust plan. Our 160-acre headquarters campus is located in Fort Worth, Texas, renowned for its warm climate, favorable cost of living, no state income tax, and a variety of educational, recreational, and cultural attractions. Please send your resume and current salary requirements to: Alcon Laboratories, Inc., Placement & Development, T1-3 (**insert appropriate code**), P.O. Box 6600, Fort Worth, TX 76115. Or fax to (817) 551-4629 and **reference appropriate code**. Or e-mail to helena.loflin@alconlabs.com and **reference appropriate code**. An Equal Opportunity Employer, M/F/D/V. Pre-employment drug testing.

Alcon® LABORATORIES

More Than Meets The Eye

OREAD

Due to our continued growth, Oread, a contract Pharmaceutical Company, is rapidly expanding capability in the chemical development area. Applications are invited for the following positions located at our Lawrence, KS operation.

PILOT PLANT MANAGER

We have recently initiated construction of a pilot plant for the manufacture of API under full GMP control. We wish to hire a pilot plant manger early in 1998 to assume responsibility for this operation. The candidate will be responsible for the completion of this project and the implementation of capital projects from design through implementation and to initiate the recruitment of the scientific and engineering staff associated with this facility. You will work in and/or lead a multi-disciplinary team environment to meet project technical and timing objectives. Qualified candidates will have a BS/Ph.D. with 10+ yrs broadly based experience in chemical development and the scale-up and transfer of multi-step synthetic chemistry manufacturing processes. Familiarity with batch processing unit operations, technical documentation and reporting and US FDA cGMP regulations are essential.

SENIOR SCIENTIST

Qualified candidates will have: Ph.D. in Organic Chemistry, 5+ yrs in multi-step organic synthesis and the isolation/identification of natural products, prior experience with chromatographic (silica gel & ion exchange) and spectroscopic (NMR,IR,MS) techniques. Prior process/scale-up experience and background in cGMPs highly desired.

Oread offers a competitive compensation package and comprehensive benefits package. For consideration, please fax or mail resume to:

SNY-1
OREAD
Attn: Human Resources
1501 Wakarusa Drive
Lawrence, KS 66047-1803
No Calls Please/EOE

FAX: (785) 832-4395

Other technical positions available. See our website at: www.oread.com

If you're looking to find your element, then come to the Additives Division of Ciba Specialty Chemicals. Our innovative products enhance the look, performance and durability of plastics, coatings, fibers, fabrics and a host of other products. We have several opportunities for technically superior professionals to participate in our success.

Technical Sales Representative

Assuming regional sales, marketing and technical responsibility for our Industrial Coatings Applications function, specifically in the area of Radiation Curing, you will negotiate agreements, plan new product introductions, prepare technical business presentations, and engage in product promotion and value-added selling. To qualify, you must have either a BA/BS, preferably in Chemistry or Chemical Engineering, and 3-6 years of experience, or MA/MS and 1-4 years of experience. Strong customer focus and technical background is essential, as are excellent communication abilities. Position requires travel. Please refer to Position KC-TS on resume.

Senior Scientists

Drawing upon your technical and strategic expertise, you will be responsible for developing and conducting state-of-the-art research projects. To qualify, you must possess a Ph.D. in Organic or Polymer Chemistry, superior analytical skills, the proven ability to develop models based upon observable phenomena, and a strong team-orientation. New product development experience is necessary, as are excellent presentation and communication skills. In addition, a background in synthetic polymer chemistry, specifically involving the translation of mechanical and physical property requirements into polymer design and architecture; or synthetic organic/ mechanistic chemistry, specifically involving polymer degradation toward designing new molecules is a must. Please refer to Position RAV on resume.

Associate Scientists

Supporting our automotive and industrial coatings business, you will design and conduct experiments involving paint formulation, application and evaluation; and measure the performance of additives in coatings. This will entail conducting spectroscopic studies and applying surface analysis techniques. To qualify, you must have either a BS in Chemistry and 3-6 years of experience or a MS with 1-4 years. Demonstrated ability to independently conduct experiments and draw meaningful conclusions is essential, as are good laboratory and housekeeping practices. Strong presentation, written communication and organizational abilities are required. PC literacy, specifically in Excel and Word, is highly desirable. Please refer to Position NC-AD on resume.

Sr. Staff Scientists

Supporting our imaging and coating additives business, you will be responsible for independently designing and performing experiments and analyzing results. You will also provide technical and strategic expertise to cross-functional project teams and supervise junior level chemists and technicians; and interact extensively with customers to determine needs, and develop new markets and technologies. To qualify, you must have a Ph.D. in Chemistry (or MS with 5-10 years of experience). Radiation curing experience/knowledge is highly desirable. Strong mechanical aptitude, excellent presentation abilities and solid communication skills are a must. A proven customer focus and willingness to travel is important. Please refer to Position KC-14/19 on resume.

How You'll Benefit

We offer excellent opportunities for professional development, salaries commensurate with experience and education, and a comprehensive benefits package.

Please send your resume and salary history to:

Human Resources-LC
Ciba Specialty Chemicals-Additives
540 White Plains Road
PO Box 2005
Tarrytown, NY 10591
fax (914) 785-4167
An equal opportunity
employer M/F/D/V

Ciba

Value beyond chemistry

DHHS/FOOD AND DRUG ADMINISTRATION/ CENTER FOR VETERINARY MEDICINE is seeking chemist to develop analytical methods for drug residues in animal tissues/fluids. Position requires experience in either chromatographic residue analysis, mass spectrometry, or pharmacokinetics. Candidates with a Ph.D. and 0-3 years experience preferred, although consideration will be given to candidates with a B.S. or M.S. degree and appropriate experience. Position is permanent and salary is commensurate with experience ($39,270-$72,758). Position is located in Laurel, Maryland. U.S. citizenship required. Please contact (301)827-4287 to receive FAX copy of vacancy announcement FDA-8-4003 or contact Mary Goodson at 301-594-0195. Candidates should submit an Application for Federal Employment (SF-171) and/or resume with transcripts to: **Food and Drug Administration, Office of Human Resources and Management Services, Room 211, Metro Park North I, HFA-423, 7520 Standish Place, Rockville, MD 20857.** Applications will be accepted through February 11, 1998. *FDA is an Equal Opportunity Employer and has a Smoke Free Environment.*

EMPLOYMENT OPPORTUNITY - ANALYTICAL CHEMISTRY

Uniroyal Chemical Company is seeking an analytical chemist with a minimum of 5 - 8 years experience in problem solving and methodology development and with a strong background in modern separation science. This position is in our central analytical laboratory at our modern World Headquarter's and Technical Center located in Western Connecticut. Here you will interface with scientists in our Rubber and Specialty Chemicals and elastomer and polyurethane businesses to solve problems and develop new analytical methodologies in support of research, process and product development and customer technical service worldwide. Our central analytical laboratory is equipped with modern instrumentation in FTIR, NMR, HRMS, GC/LCMS, GC, HPLC, CE and IC. We are presently staffed with four PhD, MS and BS chemists and several AS degree technicians. Please forward your resume with salary history and requirements to **Frank Lussier, Manager, Chemicals Characterization Laboratory, Uniroyal Chemical Company, Benson Road, Middlebury, CT 06749.** *Uniroyal Chemical is an Equal Opportunity Employer, M/F/D/V.*

CHEMISTRY. A variety of opportunities for Chemists nationwide: Pharmaceuticals, PK, Analytical, Process, QC, Synthesis, Formulations, Polymers, Coatings, Biotech, Plastics and related. Chemistry recruiting specialists since 1979. Employers pay all fees. Send resume to **LYBROOK ASSOCIATES, INC., PO Box 572, Newport RI 02840. 401/683-6990. Fax: 401/683-6355. E-mail: chemistry@lybrook.com.** Check our Website: http://www.lybrook.com

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ESCA/SAM SCIENTIST

The Characterization Science & Services Directorate of Corning Incorporated Science & Technology Division seeks to hire a scientist with PhD in Materials Science or Chemistry with 5+ years of ESCA experience beyond the doctorate. The successful applicant must be an expert in the utilization of ESCA/SAM in solving materials and process problems. We are seeking an individual who has a proven track record in defining characterization needs, developing an analytical strategy, and implementing it in a timely manner. Excellent hands-on laboratory skills in surface characterization is a must. The successful individual must communicate well with materials scientists within the research organization, and be able to create collaborative research projects on problems of interest. Corning is a producer of technical glass, ceramic, and polymer products, and has a long standing reputation of advanced scientific invention and development of related materials. Resumes should be submitted to: **David C. Larsen, SP-FR-4, CORNING INCORPORATED, Corning, NY 14831** *Corning is an Equal Opportunity Employer*

SYNTHETIC ORGANIC CHEMIST— Kelly Science Resources has available positions for individuals for assignment at Eli Lilly and Company in Indianapolis, Indiana. Successful **MS/BS** candidates will have significant laboratory experience in Organic Chemistry with emphasis on Organic Synthesis, experience in medicinal chemistry is also highly valued. For immediate consideration please FAX resumes to **Shayne Small at (317) 630-3674.**

Magainin Pharmaceuticals Inc.

...is a rapidly developing biopharmaceutical company engaged in R&D of pharmaceuticals against serious diseases. We are seeking a scientist with commitment, excellent training and communication skills to expand our drug research and development efforts in the following key area:

Director, Analytical Chemistry

We are seeking an experienced pharmaceutical analyst to Direct our Analytical Department. The ideal candidate will join our Analytical Group and be responsible for analysis of all Magainin development candidates. The Director will supervise the development of methods to support Magainin drug substances, drug products and pharmacology through bio-analytical methods. A comprehensive background in drug substances and dosage form quality criteria is required for this position. The programs are based in our library of peptide analogs and amino-steroid development candidates and include topical, oral and parenteral dosage formulations. The Director will manage the analytical chemists and assure accuracy of results through documentation and validation. The ideal candidate will have a Ph.D. degree in Chemistry and at least 7 years experience with pharmaceutical analysis. We are looking for someone who actively participates in the technical decisions associated with analytical development.

For consideration, please submit your resume to **Human Resources, Magainin Pharmaceuticals Inc., 5110 Campus Drive, Plymouth Meeting, PA 19462.** MPI offers excellent compensation and benefits. Equal Opportunity Employer. No phone calls please.

A Commitment to EXCELLENCE. The Pursuit of INNOVATION. A Sense Of ACCOMPLISMENT.

At Eli Lilly and Company, we've been driven by a commitment to excellence and the pursuit of innovation ever since we began researching and developing novel pharmaceuticals more than a century ago. Our investment in advancing health care and medical science has led to unprecedented industry leadership as our $7 billion corporation now markets products in 150 countries and employs nearly 30,000 dedicated professionals around the world. Everything we accomplish is a credit to our people and we instill this sense of ownership in each and every one of them. If you want to pursue your career with a company that continues to accomplish everything it sets out to achieve

Associate Scientist - Infrared

BA/BS/MS scientist is sought with technical knowledge and experience with infrared instrumentation, sample preparation, and microscopy for application in particulate identification, assessment of proteins and peptides, and method development. High quality written and verbal communication skills are required. The IR scientist will be expected to expand his/her expertise into one of three other areas, biophysical characterization of proteins and peptides, analytical method development, or parenteral product development

An excellent salary. A comprehensive benefits package. A sense of pride. You'll enjoy all this and more when you join us at Lilly. For immediate consideration, please send your resume to: Eli Lilly and Company, Biopharmaceutical Technology Development, 314/4 DC 3844, Lilly Corporate Center Indianapolis, IN 46285. We are an equal opportunity employer dedicated to diversity in the workplace.

Lilly
Eli Lilly and Company

Knowledge Is Powerful Medicine

Polymeric Materials Research Engineer

Kimberly-Clark is a Fortune 100 recognized global leader in the manufacture of personal care, health care, tissue, and specialty paper products with total sales of over 14 billion dollars. The company has manufacturing operations in 35 countries and sells products in more than 150 countries.

We are seeking individuals to join our R&D organization in materials research. Qualified candidates will have a Ph.D. or M.S. degree in mechanical, materials, or chemical engineering with expertise in polymeric material mechanics and 2-10 years of relevant work experience (beyond academic training). Candidates must have a demonstrated track record of innovation and the ability to handle challenging and complex research problems. The ability to use modeling tools is a definite plus.

Qualified candidates must also be highly motivated, creative professionals with excellent communication, interpersonal, and team building skills.

This unique opportunity is located at our R&D campus in Neenah, Wisconsin. We offer a competitive salary and benefit package commensurate with education and demonstrated track record. For consideration, please send your resume in confidence to: Technical Recruiting-GDW, Kimberly-Clark Corporation, 2100 Winchester Road, Neenah, WI 54956. An Equal Opportunity Employer. Principals only.

Kimberly-Clark Corporation

COME TO BIOTECH BEACH

Alliance Pharmaceutical Corp. is a leader in the development of liquid breathing technology, blood substitute emulsion & other technologies. We are located in San Diego, known as Biotech Beach because of its ideal coastal location & innovative scientific advances. We seek:

SENIOR RESEARCH SCIENTISTS

Develop commercial formulation; provide documentation; devise & execute SOPS/guidelines; supervise Jr. Scientists. Must have PhD in Pharmaceutics, Industrial Pharmacy or 2-5+ yrs' exp in related field.

- **Preformulation Development** - Requires working knowledge of analytical instrumentation & processing equipment used in preparation of experimental formulation. Exp in formulation/characterization of dry powders &/or rheology desirable. Code: 036A
- **Formulation Development** - Must be proficient in running typical analytical instruments, HPLC & particle size analyzers. Code: 036

RESEARCH SCIENTIST/STABILITY

Coordinate formulations; analyze stability studies; generate protocols; monitor results; provide recommendations; prepare statistical analysis & documentation. Requires BS/MS in Chemistry or related field; 2-5+ yrs' exp monitoring, planning & designing stability studies relative to pharmaceutical dosage forms & drugs; familiarity w/ US-FDA & ICH guidelines. Code: 037

We offer competitive salaries & benefits & an attractive environment. Submit resume w/ cover letter & salary history, indicating Code: (see above), to: c/o A&M Consulting, 3675 Ruffin Rd, Ste 225, San Diego, CA 92123; or fax to: (619) 505-0445. Website: www.allp.com. No phone calls please. EOE

Alliance PHARMACEUTICAL CORP.

RESEARCH CHEMICAL ENGINEER - EXTRACTION

Eastman Chemical Company's Research Laboratories is seeking a new member for our Separations Team to direct the program in liquid-liquid extraction. Members of this team work on multidisciplinary teams that focus on all business and technical aspects of new product/process development.This person will also lead efforts in the research, development, design, and optimization of separations involving extraction. He/She will serve as an expert consultant to many of our plant sites (domestic and foreign) and represent Eastman at international topical conferences. The successful candidate will have a Ph.D. in Chemical Engineering, be self motivated, enjoy applied research, communicate effectively, and have both experimental and theoretical experience in liquid-liquid extraction. Awareness of the state-of-the-art in international research in extraction is essential. Eastman Chemical Company, a Fortune 500 company, employs approximately 350 PhD scientists and engineers and is a major manufacturer of plastics, fiber, and organic chemicals. This position is located at our central research laboratories in Kingsport. Kingsport is in the Tri-Cities area of northeast Tennessee. This area is rated among the top 25 most livable metropolitan areas and offers affordable housing, low taxes, and excellent schools including a nearby state university. The pleasant four-season climate in the foothills of the Smoky Mountains permits a variety of outdoor recreational opportunities, such as boating, fishing, hiking and water or snow skiing. Interested candidates should respond by February 9, 1998 by sending their resume to: **EASTMAN CHEMICAL COMPANY, Employment Department - LJ5, P.O. Box 1975, Kingsport, TN 37662-5215** *Eastman Chemical Company is an Equal Opportunity/Affirmative Action Employer.*

SURFACE SCIENCE LABORATORIES provides analytical services for failure analyses, materials characterization, and QA/QC using sophisticated analytical equipment. Our continued growth has created the need for an experienced RAMAN/FT-IR analyst. The position requires a minimum of a BS in chemistry, physics or a related field and at least 4 to 6 years of specific hands-on experience in RAMAN and FT-IR techniques. Excellent communication skills (oral and written) are mandatory. An advanced degree is preferred. Please send your resume to **Surface Science Laboratories, 625 By Clyde Avenue, Mt. View, CA 94043, fax to (650) 919-0669 or e-mail to sfarrell@surface-science.com.** *EOE*

Agricultural Research Service — United States Department of Agriculture

RESEARCH SCIENTISTS OR RESEARCH ENGINEERS,

GS-11/12/13/14/15 National Center for Agricultural Utilization Research (NCAUR), Biomaterials Processing Research Unit, Peoria, Illinois. NCAUR has five research positions available within a multi-disciplinary team to develop fundamental knowledge concerning the utilization of biopolymers from agricultural commodities. The team will carry out basic and applied research on the chemical and thermomechanical modifications of starch and proteins for new food and industrial applications. Potential disciplines to be considered include: **materials science, polymer physics, rheology, polymer chemistry, organic chemistry, chemical engineering, process engineering, molecular and process modeling.** Other disciplines will be considered as well. All positions require professional research experience and/or directly related education with proven ability to plan, conduct, and report independent research in the specialty area, while working within a research team environment. Salary is commensurate with experience ($37,507-$96,594). Negotiable hiring incentives are possible. U.S. Citizenship required. Ph.D. preferred. More information about ARS is available at http://www.ars.usda.gov on the ARS Home Page. For information about the research programs, contact **Dr. Peter Johnsen at (309) 681-6541.** Please submit resume or CV, copies of transcripts, list of publications, and accomplishments to: **A. Hegarty, Ad #3620-50, USDA-AFM-Human Resources Division, Northern Operations Branch, 6305 Ivy Lane, Room 325, Greenbelt, MD 20770.** Applications must be postmarked by February 28, 1998. *USDA/ARS is an equal opportunity employer.*

CHEMIST

A bio-tech Co. is seeking a Sr. Chemist w/4-8 years exp. in organic and solid phase peptide synthesis. Automatic peptide synthesizer, HPLC purification, large scale synthesis and lab supervision experience will be helpful. Resume to **AnaSpec 2149F O'Toole Ave., San Jose, CA 95131, or Fax 408-452-5059**

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At Eli Lilly and Company, science and technology are the best of partners brought together for one purpose: to help people all over the world live healthier, happier lives. For well over 100 years, we've been known as a visionary in the sophisticated world of pharmaceuticals. We're bringing that same degree of intelligent effort and wholehearted commitment to the technology we develop. Technology that supports our cross-functional global teams in their diverse and innovative projects.

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RESEARCH TECHNOLOGY AND PROTEINS

Postdoctoral Fellow – Computational Chemistry

Lilly Research Laboratories has a position available in computational chemistry to develop and to apply computational methods to combinatorial chemistry. The appointment will be for a period of 1 to 2 years. Candidates for this position should have a Ph.D. or equivalent with a strong research background and experience in computational or physical chemistry. Candidates must be fluent in computer programming languages and workstation environments, have a working knowledge of QSAR, genetic algorithms and neural networks, and have good interaction skills. Candidates would be expected to function in a multidisciplinary group composed of medicinal chemist, computational chemist, computer scientist, and statisticians.

Postdoctoral Fellow – Synthetic Organic Chemistry

The postdoctoral fellow will be responsible for designing and executing chemical reactions for combinatorial analog synthesis of natural product scaffolds. Candidates should have a recent Ph.D degree in synthetic organic chemistry with experience in modern separation and analytical techniques. Prior experience in combinatorial synthesis and familiarity with natural products, though not required, are highly desirable.

Postdoctoral Fellow – NMR

A position is available in the area of drug design using NMR spectroscopy. A candidate will be expected to develop new applications for "SAR by NMR", particularly around the addition of NOE to this technique. The research will be performed as a collaboration with the chemical libraries group and will have access to a Varian 500 equipped with sample changer. Interested applicants for this postdoctoral position should have background in solution state NMR, either protein or small molecule, and experience in synthetic organic chemistry. Training in protein cloning and purification would also be an advantage.

Qualified candidates for the above positions may send resumes to: **Eli Lilly and Company, Chemistry Research Technology and Proteins, Manager, (Postdoctoral Applications DC 1533), Indianapolis, IN 46285.**

CHEMICAL PROCESS RESEARCH AND DEVELOPMENT

Three Organic Chemistry Postdoctoral Fellows

We have three organic chemistry postdoctoral fellow positions available in Chemical Process Research and Development at Eli Lilly and Company. Preference for these two year positions will be given to individuals with experience in 1) multi-step synthesis, synthetic methodology, and organometallic chemistry, 2) transition metal carbon-carbon bond forming reactions, and 3) synthetic modification, characterization and use of polymer based reagents. Candidates should have strong technical, problem solving, communication, and self-management skills. Must be able to thrive in a team environment. These positions provide an excellent career development opportunity in an exciting pharmaceutical organic chemistry environment, with competitive salary and benefits in a metropolitan area.

For the Organic Chemistry position, please send letter, complete vita, and the identity of three letters of reference to: **Eli Lilly and Company, Chemical Process Research and Development, Department Head, (Postdoctoral Application, DC4813), Indianapolis, IN 46285.**

For more information, please visit our Web site: http://www.lilly.com. We are an equal opportunity employer dedicated to diversity and the

Lilly
Eli Lilly and Company
KNOWLEDGE IS POWERFUL MEDICINE

INORGANIC LABORATORY MANAGER- TriMatrix Laboratories, Inc., a Grand Rapids, MI based leader in the environmental testing industry, is seeking a qualified individual to manage our Inorganic Lab. Responsibilities include development and management of all inorganic chemists, implementation of quality systems, scheduling, technical development, and data approval. Must be experienced in USEPA Methods with emphasis on ICP/MS, ICP, FN-AA, and wet chemistry procedures. Experience with Perkin Elmer equipment and CLP protocols a plus. Background/educational requirements includes a BS degree in Chemistry and 8 or more years, or MS degree in chemistry and 6 or more years, of experience in an environmental laboratory. We offer a professional work atmosphere and competitive salary/benefits package. Qualified candidates submit resume and salary requirements via mail, email or fax to: **Human Resources Manager: TriMatrix Laboratories, Inc., PO Box 888692, Grand Rapids, MI 49588-8692/Fax #: (616) 940-4316/email: trimatrx@iserv.net** *TriMatrix Laboratories, Inc. is an Equal Opportunity Employer.*

TRITON SYSTEMS, INC. seeks two hands-on people that can thrive in a fast paced multidisciplinary environment with minimal supervision and possess good written and verbal communication skills. Qualified applicants should send a cover letter and resume to: **Triton Systems, Inc., Polymer Technology Group, 200 Turnpike Road, Chelmsford, MA 01824, or tech-job@tritonsys.com. CONDUCTIVE POLYMER SCIENTIST** with a Ph.D. in Chemistry with 3-10 years experience to support applied R & D programs in conductive polymers. Experience with conductive polymer synthesis and characterization, blending of conductive polymers, fabrication of electrochromic devices, and electrochemical deposition of conducting polymers is essential. Please reference job CONDUCTIVE POLYMER SCIENTIST. **CHEMIST** with a B.S. or M.S. in Chemistry with 2-5 years experience to support applied R & D programs which utilize a wide range of materials. Experience with polyarylene ether synthesis and characterization, and/or electrochemistry is essential. Please reference job CHEMIST.

INDUSTRIAL POSITIONS

RESEARCH ASSOCIATES

LIGAND Pharmaceuticals Inc. is a leader in applying gene transcription technology based on Intracellular Receptors (IRs) and Signal Transducers and Activators of Transcription (STATs) to the discovery and development of small molecule drugs. Our mission is to create products that address major unmet patient needs in cancer, women's health and skin diseases, as well as cardiovascular and inflammatory diseases. We employ state-of-the-art drug design techniques, modern pharmacology and cutting-edge molecular cell biology in an integrated approach to drug discovery. Currently, we seek outstanding individuals to join us in the following area:

SYNTHETIC/MEDICINAL CHEMISTRY

Successful candidates will contribute their talents to a team of chemists responsible for the synthesis, isolation and structure elucidation of novel non-peptide organic molecules undergoing biological evaluation. A BS/MS degree in Chemistry is required along with 1-3 years of laboratory experience in the synthesis of organic molecules, including a background in chromatographic and spectroscopic techniques (HPLC, NMR).

LIGAND, located in La Jolla's Golden Triangle of San Diego, offers an attractive salary and benefits package, including stock options. Please fax or mail your resume to: LIGAND Pharmaceuticals, Dept. CB, 10275 Science Center Drive, San Diego, CA 92121. Fax (619)550-7800. EOE.

LIGAND
PHARMACEUTICALS

KINGDOM OF SAUDI ARABIA
SAUDI BASIC INDUSTRIES CORPORATION (SABIC)

SABIC has an opening in our world class Industrial Research & Development Complex, located in Riyadh, Saudi Arabia. This dynamic and growing complex is the SABIC corporate leader in technology development, technical support services and customer product services. SABIC is a leading international producer of plastics, fertilizers and other petrochemical products. Staff have exciting and challenging opportunities in process, maintenance, operations, product and scientific problems.

CATALYSIS SCIENTIST

Candidate must have a Ph.D. in Chemistry or Chemical Engineering with 3-5 years of R&D experience in the preparation, characterization and application of homogenous and heterogeneous catalysts. Preference given to candidates with proven research experience in the area of activation of light alkanes to produce commercially useful chemicals. Hands-on experience in the design and operation of bench scale and pilot reactors is highly desirable. Selected candidates will be responsible for developing new catalysts and catalytic processes or proposed chemical products.

We offer challenging jobs, excellent work environment and an attractive compensation package. Benefits include relocation allowance, educational allowance, housing, life and medical insurance, annual paid home leave and transportation allowance.

Interested candidates should send a full resume of experience and qualifications, summary of project and technical achievements and salary requirements within 15 days of this advertisement. You must include the position number and position title in all correspondence if you desire your resume to be considered. Please no phone calls or FAXED resumes.

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ACADEMIC POSITIONS

INRS
LA FORCE DE LA SCIENCE

PROFESSEURS(ES)-CHERCHEURS(ES)

L'INRS-Énergie et Matériaux, centre de recherche et de formation de 2e et 3e cycles, recherche des spécialistes dans les domaines de l'énergie, des matériaux et de l'interaction laser-matière.

Concours SP 97-69:
Un(e) professeur(e)-chercheur(e) dans le domaine des nouveaux matériaux, procédés et dispositifs applicables à la production, le stockage, le transport et l'utilisation de l'énergie.

Concours SP 97-70:
Un(e) professeur(e)-chercheur(e) dans le domaine de l'interaction laser-matière et des applications des sources laser ultra-rapides (haute puissance et/ou haut taux de répétition).

Concours SP 97- 71:
Un(e) professeur(e)-chercheur(e) dans le domaine de la microfabrication pour le développement de dispositifs.

Pour plus d'informations, consulter le site internet : http ://www.inrs.uquebec.ca

EXIGENCES : Détenir un doctorat dans une discipline reliée aux sujets de recherche proposés et avoir démontré des qualités d'expérimentateur.

La langue de travail est le français.

LIEU DE TRAVAIL :
INRS-Énergie et Matériaux
1680, boulevard Lionel-Boulet
Varennes (Québec)

Prière de faire parvenir votre curriculum vitae complet, trois lettres de référence et les documents pertinents en y indiquant le numéro du concours auquel vous participez, avant le 31 mars 1998, au :

Directeur des ressources humaines
Institut national de la recherche scientifique
Place de la Cité, Bureau 640
2600, boulevard Laurier, Case postale 7 500,
Sainte-Foy (Québec) G1V 4C7
DIR_RHUM@INRS.UQUEBEC.CA

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Université du Québec
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SPECIAL ISSUE:
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ACADEMIC POSITIONS

UNIVERSITY OF ROCHESTER
FACULTY POSITION IN THE DEPARTMENT OF CHEMICAL ENGINEERING AND THE BIOMEDICAL ENGINEERING PROGRAM

The Chemical Engineering Department at the University of Rochester invites applications for a new tenure-track position in Chemical and Biomedical Engineering to he filled at the Assistant Professor level. Exceptional candidates qualified for higher ranks will also be considered. We hope to fill this position by June 1998. Applicants must have earned the Ph.D. degree in Chemical Engineering or a closely related area. Significant postdoctoral training will be viewed positively. Preference will be given to applicants whose research interests will augment existing strengths in the areas of tissue engineering, biofluid mechanics, and biomaterials, although outstanding candidates with general research interests in the chemical engineering aspects of biomedical engineering will also be considered. Successful candidates will be expected to develop independent, extramurally funded research programs and to participate fully in the chemical and biomedical engineering teaching programs. The University of Rochester has recently instituted degree programs in Biomedical Engineering at the doctoral, masters and bachelor of science levels and new faculty are needed to help support these programs. In addition to the current opening, a junior level faculty member in biomedical engineering recently was added to the Mechanical Engineering Department and another faculty member is being recruited in the Department of pharmacology and Physiology in the School of Medicine and Dentistry. Review of candidates will begin immediately and will continue until the position is filled. Applicants should send their curriculum vitae, three recent reprints, a statement of research interests and plans, and the names of three referees to **Harvey J. Palmer, Chair, Department of Chemical Engineering, University of Rochester, 206 Gavett Hall, Rochester, New York 14627-0166.** For information about the chemical and biomedical engineering programs, access our web sites through http://www.seas.rochester.edu:8080/. *The University of Rochester is an Equal Opportunity/Affirmative Action Employer; applications from women and underrepresented minorities are encouraged.*

NATIONAL CENTRAL UNIVERSITY (IN TAIWAN): The Department of Chemistry invites applications for both senior and junior faculty positions in **Analytical** chemistry, **Atmospheric** chemistry and **Inorganic** chemistry, although truly outstanding candidates in any area of chemistry will be considered. All appointees are expected to pursue an active research program and have a strong teaching commitment. A Ph.D. in Chemistry and postdoctoral experience are required. Please send C.V., three letters of recommendations, description of research plans by March 31, 1998 to: **Chairman, Department of Chemistry, National Central University, Chung-Li Taiwan, ROC. Fax: + 886-3-422-7664.**

FACULTY POSITION:PHYSICAL CHEMISTRY

The Department of Chemistry & Physics at Beaver College invites applications for a full-time, tenure track position in physical chemistry, beginning September 1, 1998. The successful candidate must have a Ph.D. in Physical Chemistry, demonstrated excellence in teaching, and a strong record of scholarly activity. Development of an active research program involving undergraduate students is expected. Interested applicants should send curriculum vitae, transcripts, three letters of recommendation, and a statement of research interests to **Dr. C. M. Mikulski, Chair, Department of Chemistry & Physics, Beaver College, Glenside, PA 19038** by February 13, 1998. *EO/AA employer.*

FACULTY APPOINTMENT-TENURE TRACK

Bellevue Community College (BCC), a two-year college in the Puget Sound region of Washington state, invites applications for a teaching position in chemistry to begin Fall Quarter 1998. The college is the largest community college in the state. BCC is diverse, innovative, and renowned for quality instruction. A Masters Degree in Chemistry is required. For an application packet, call our Jobline at 425-643-2082 or visit website: www.bcc.ctc.edu/joblist. Application deadline February 9, 1998 or until filled. *BCC is an Equal Opportunity Employer and operates under an Affirmative Action Plan.*

INDUSTRIAL POSITIONS

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We're Baxter International, a global medical products and services company that is a leader in technologies related to the blood and circulatory system. We are proud to hold market-leading positions in four global businesses: *biotechnology, cardiovascular medicine, renal therapy, and intravenous systems/ medical products.* We currently have the following opportunities available in the Corporate Research and Technical Services Division near the beautiful Chain of Lakes area in Round Lake, Illinois. Round Lake, a Northern Suburb of Chicago, is within easy access of Milwaukee, WI, which puts you right in the heart of the Midwest's cultural, entertainment and educational offerings.

POLYMER PHYSICIST

This hands-on Scientist/Engineer will function as a consulting materials specialist on company-wide material programs while conducting and directing physical materials testing and evaluation protocols and process development activities. Your main focus will be to lead and/or participate in multi-functional task groups working on product design, problem solving or technical reviews. Project or task management skills leading to achievement of customer requirements on technical milestones, project or task budget limits and timely delivery of contracted results are essential.

We require an advanced degree in Polymer Science or Engineering with a minimum of 5-10 years experience in polymer morphology (including SEM, TEM analysis), thermal analysis, rheology, failure analysis, and product development. Excellent interpersonal and communication skills are required as you will be working closely with various customer and supplier groups on all levels.

TECHNICAL FELLOW

The Engineer/Scientist we seek will participate in multi-functional design and development teams encompassing all facets of the product development process with a unique emphasis on individual contributions. Program possibilities include environmentally friendly biomedical material development, proactive process and product improvements, and value-added problem resolution for customers.

The ideal candidate is a recent Ph.D in Polymer Science or Engineering with thesis research in polymer physics, chemistry, or processing. Effective interpersonal and communication skills are essential.

We offer a competitive salary and benefits package in a professionally challenging, rewarding environment. As part of career growth, we encourage appropriate publication and presentation of advances in material and biomedical sciences. For consideration, please send your resume to: **Baxter Healthcare Corporation, Corporate Research and Technical Services Division, Job Code: CRT9714026, Route 120 & Wilson Rd., Round Lake, IL 60073. Fax: 847-270-5742. E-mail: cobbc@baxter.com.** EOE M/F/D/V

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ACADEMIC POSITIONS

THE DEPARTMENT OF CHEMISTRY AT OUR LADY OF THE LAKE UNIVERSITY OF SAN ANTONIO invites applications for a faculty position at the Assistant Professor level beginning in August 1998. The successful candidate will be responsible for implementing an undergraduate research program and improving the undergraduate curriculum by implementing courses in physical chemistry and instrumental analysis. A Ph.D. is required as well as a strong commitment to teaching at the undergraduate level. Additional information is available at the bottom of OLLU's homepage at http://www.ollusa.edu. By February 13, 1998 send resume, graduate transcipts, description of teaching philosophy, description of research projects for undergraduates, and three letters of recommendation to **Sr. Isabel Ball, Dean, College of Arts and Sciences, Our Lady of the Lake University, 411 SW 24th Street, San Antonio, Texas 78207-4689.** OLLU seeks employees who understand and are committed to the values of Catholic higher education. *We are an affirmative action/equal opportunity employer.*

ACADEMIC POSITIONS

POSTDOCTORAL POSITION-CHEMICAL TOXICOLOGY. A postdoctoral position is available immediately to study the biotransformation and bioactivation of halogen- and sulfur-containing chemicals. Information about our research program can be found on the Web (http://www.pharmacol.rochester.edu/faculty/scroll to Anders). Candidates should have earned a Ph.D. degree in medicinal, pharmaceutical, or organic chemistry, have experience in enzymology, analysis (NMR, GC/MS), and organic synthesis, and must be willing to work with laboratory animals. The initial appointment is for 1 year and can be extended by mutual agreement. Applicants should send or e-mail (anders@pharmacol.rochester.edu) their curriculum vitae and the names of three referees to: **Dr. M. W. Anders, Department of Pharmacology and Physiology, University of Rochester Medical Center, 601 Elmwood Avenue, Box 711, Rochester, NY 14642.** The search will remain open until the position is filled. *The University of Rochester is an equal opportunity/Affirmative Action employer.*

INDUSTRIAL POSITIONS

Chemistry

Intense commitment, a passion for discovery, leading-edge resources.

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In the world of healthcare, few companies are in a position to do so much for so many as Hoffmann-La Roche. Our mission is to identify and satisfy the healthcare needs of the world. In our never-ending quest for innovative products, we exercise imagination, ingenuity and an uncompromising pursuit of discovery.

Hoffmann-La Roche's dedication to the future is evident in our commitment to the research, development and manufacture of pharmaceuticals worldwide. Hoffmann-La Roche recognizes the pivotal role of chemistry research in the drug discovery process and has several opportunities for synthetic organic chemists to join specific drug discovery teams at our U.S. headquarters located in Nutley, New Jersey.

These teams, through a broad array of technologies, are pursuing novel drug targets in the areas of inflammation, metabolic disease and cancer.

Scientists - BS/MS Chemists

As a member of our multidisciplinary drug discovery team, you will participate in the design, synthesis and characterization of target compounds using modern separation and spectroscopic techniques. To qualify, you must have a BS or MS degree in organic chemistry and combined experience in multi-step synthesis with a strong understanding of theoretical chemistry. These positions also require effective oral and written communication skills.

At Roche, we not only offer employees competitive salaries and comprehensive benefits, we also offer a unique campus-like facility, a state-of-the-art fitness center and on-site child care. For consideration, forward your resume to: **R&D Human Resources, Hoffmann-La Roche, Dept. SSO112JT, 340 Kingsland Street, Bldg. 76/508, Nutley, NJ 07110.** We appreciate your interest in Hoffmann-La Roche but can only respond to qualified candidates. Hoffmann-La Roche is an equal opportunity employer fully committed to diversity in the workplace.

Roche

ACADEMIC POSITIONS

TWO FACULTY POSITIONS - COMPUTATIONAL & PHYSICAL CHEMISTRY effective August 1998. The Department of Chemistry at Jackson State University,seeks a Computational Chemist and Physical Chemist (all areas of expertise will be considered) at the Assistant Professor level. Duties include teaching at the undergraduate and master levels and development of a strong research program. A Ph.D. degree is required, postdoctoral experience desirable. Send resume, undergraduate and graduate transcripts, statement of teaching philosophy, detailed research plan and three letters of reference to: **Dr. Richard H. Sullivan, Chair, Department of Chemistry, Jackson State University, P.O. Box 17910, 1325 J.R. Lynch Street, Jackson, MS 39217-0510 by February 28, 1998. (e-mail: sullivan@tiger.jsums.edu).** Information on JSU available at http://stallion.jsums.edu/. Search will continue until positions are filled. *An EO/AA employer.*

ACADEMIC POSITIONS

CHEMISTRY INSTRUCTOR

Santa Monica Community College is accepting applications for a full-time, tenure-track Chemistry Instructor for Fall semester, 1998. The selected candidate will teach introductory and chemistry lecture and laboratory courses and develop laboratory experiments and demonstrations. Background in inorganic, physical, analytical or organic chemistry preferred. Master's in chemistry or Bachelors in chemistry and Master's in biochemistry, chemical engineering, chemical physics, physics, molecular biology or geochemistry or the equivalent. $34,148 - $70,330. Deadline date to be determined. Please call (310) 452-9336 for a district application and detailed job description or write to **the Office of Academic Personnel, Santa Monica Community College, 1900 Pico Blvd., Santa Monica, CA 90405,** *AA/EOE.*

ACADEMIC POSITIONS

RESEARCH
POSTDOCTORAL FELLOW:
BIOCHEMIST, MEDICINAL,
CHEMIST OR EQUIVALENT

Applicants with strong commitment to research are encouraged to apply. Research will be focused on understanding the role of selective environmental agents on the development of breast cancer. Studies will include but not be limited to: (1) study carcinogen-macromolecular interactions, (2) develop sensitive methods to monitor human exposure to carcinogens. The American Health Foundation is an internationally recognized research center for disease prevention & helath promotion. Please send resume to: **Box KELB, American Health Foundation, 1 Dana Road, Valhalla, New York 10595.** *EEO M/F/H/V/ADA*

POSTDOCTORAL POSITION - Synthesis of organosulfur compounds as treatments for exposure to chemical hazards. Requires familiarity with heteroatom chemistry, esp. sulfur, and hands on nmr and hplc experience. Available ca. 2/15/98. Send resume and arrange for three supporting letters to be sent to **Prof. A. L. Ternay, Jr., Dept. of Chemistry, Box 19065, Univ. Texas at Arlington, Arlington, TX 76019. email: ternay@uta.edu FAX: 817 272-3808 Voice: 817 272-3818.** *AA/EO Employer.*

CHEMISTRY

Physical/Analytical Chemistry Faculty Position at the Assistant Professor level. Ph.D. required. Sabbatical leave replacement for the 98/99 academic year. To teach year long courses in Physical Chemistry and Instrumental Methods of Analysis. Teaching experience preferred. Each course includes three hours of lab per week. Participation in undergraduate research and other departmental programs expected. Washington College is a small liberal arts institution (1100 students), located in Chestertown, on Maryland's Eastern Shore, within a 90 minute drive of Washington, DC, Baltimore and Philadelphia. Please forward resume, graduate school transcripts, and three letters of reference by Feb. 15 to **Dr. Rick Locker, Acting Chair, Chemistry Department, Washington College, 300 Washington Ave., Chestertown, MD 21620-1197.** Inquiries answered at **rick.locker@washcoll.edu.** *Equal Opportunity Employer. Women and minorities are encouraged to apply.*

ASSISTANT PROFESSOR. The Department of Basic Pharmaceutical Sciences of the West Virginia University School of Pharmacy invites applications for a 12-month tenure-track position. We are interested in recruiting in one or more of the areas of computation chemistry, novel drug delivery systems, drug metabolism, or free radical biology. The successful applicant will be expected to develop and maintain an extramurally funded research program. Teaching is required. Ph.D. degree, or equivalent, and postdoctoral experience required. Application review will begin January 1, 1998 and the search will continue until the position is filled. Send C.V., a letter outlining research plans, and names and addresses of 3 references to: **Dr. Patrick Callery, West Virginia University, Basic Pharmaceutical Sciences, P.O. Box 9533, Morgantown, WV 26506-9530.** *WVU is an Equal Opportunity/Affirmative Action/ADA Employer.*

TEACHING, RESEARCH FELLOWSHIPS for Ph.D. program. Well-equipped department. Inorganic, physical, organic, theoretical, analytical, and biochemistry. Starting September 1998: $16,560/12 months plus free tuition. **Chemistry Department-CN, Georgetown University, Box 571227, Washington, DC 20057-1227. (202) 687-6073. FAX: (202)687-6209. http://www.georgetown.edu/departments/chemistry/chemistry.html**

POSTDOCTORAL POSITIONS

Postdoctoral opportunities available in several areas: 1) a bio-molecular database for the WWW — familiarity with binding assays useful; 2) new computational methods with focus on molecular recognition — computational skills required; 3) Development of modeling software. Please send CV, references, and description of interests and goals to: **Dr. Michael K. Gilson, CARB, 9600 Gudelsky Drive, Rockville, MD 20850-3479, gilson@indigo14.carb.nist.gov, http://indigo15.carb.nist.gov/carb/carb.html.** *Preference will be given to U.S. citizens for certain NIST-funded positions.*

ACADEMIC POSITIONS

DIRECTOR
CENTER FOR DIAGNOSTICS AND DRUG DEVELOPMENT
UNIVERSITY OF CENTRAL FLORIDA

The University of Central Florida (UCF) seeks candidates to direct and develop the newly created Center for Diagnostics and Drug Development. The Director will report to the Vice President for Research and Graduate Studies. The successful candidate will provide academic leadership, vision, direction and coordination of multidisciplinary research programs in establishing the Center as a national leader in research and graduate education. The Director is expected to maintain strong collaboration with on campus academic units, including appropriate deans and chairs. The Director is also expected to develop a sound funding base from public and private industry. Faculty appointment as commensurate with credentials. The successful candidate should possess an appropriate advanced degree in Chemical and/or Biomedical Sciences with a sustained record of scholarly accomplishments in academia and/or industrial settings. Preference will be given to candidates demonstrating: excellent communications and interpersonal skills; strong planning and decision-making capabilities; an excellent track record of research funding; an ability to lead a multi-investigator research program; knowledge of patent and licensing issues. UCF currently enrolls over 28,000 students and is among the fastest growing universities in the nation. The main campus is located in Orlando, one of the nation's most dynamic metropolitan areas and fastest growing centers for technology-based industries. Nominations or applications should include the curriculum vitae of the candidate. Review of candidates will begin March 1, 1998 and will continue until a successful candidate is identified. Please address all applications and nominations to: **Dr. Michael Sweeney, Chair of the Center for Diagnostics and Drug Development Search Committee, University of Central Florida, College of Health and Public Affairs, P.O. Box 162200, Orlando, FL 32816-2200** *UCF is an equal opportunity/affirmative action employer.* As an agency of the State of Florida, UCF makes all application materials, including transcripts used in final screening, available to the public upon request.

TENURE-TRACK FACULTY POSITION AT CARB
BIOINFORMATICS/COMPUTATIONAL BIOLOGY

Applications are invited for a tenure-track faculty position at the Center for Advanced Research in Biotechnology (CARB). We are particularly interested in applicants who use computational methods to derive new information from existing sequence and structure data, and in applicants developing computer models of cellular and subcellular processes. The successful candidate will be expected to establish a strong, independent, externally-funded research program. CARB is a research center of the National Institute of Standards and Technology (NIST) and the University of Maryland Biotechnology Institute (UMBI). CARB is devoted to fundamental studies of macromolecular structure, function, and engineering, and offers opportunities for collaboration with scientists involved in high-field NMR spectroscopy; physical biochemistry; structural immunology; protein folding, stability, modeling and engineering; macromolecular crystallography; and computational chemistry. Interested candidates should send a curriculum vitae, a summary of research interests and plans, and arrange for at lease three letters of reference to be sent to: **Bioinformatics Search Committee, Center for Advanced Research in Biotechnology, University of Maryland Shady Grove Campus, 9600 Gudelsky Drive, Rockville, MD 20850.** Review of applications will being on February 1, 1998. *CARB is an Equal Opportunity/Affirmative Action Employer. Women and minority candidates are encouraged to apply.* This is a NIST funded position. Preference will be given to U.S. citizens.

CHEMIST/SOFTWARE DEVELOPER: Postdoc/Research Associate at McGill University developing expert systems and other "artificially intelligent" programs to be used for Inductively Coupled Plasma-Mass Spectrometry. Strong programming skills necessary and experience in ICP spectroscopy desirable. Applicant is expected to assume a leadership position. Position is for one year with possibility for two additional years. Salary depends on qualifications and demonstrated performance. Contact **Prof. Eric Salin 514 398 6236, salin@omc.lan.mcgill.ca.**

INDUSTRIAL POSITIONS

Delivering The Science That Delivers The Drugs.

Alkermes is committed to becoming one of the world's premier drug delivery companies. In addition to being a leader in the development of injectable sustained-release microsphere formulations, Alkermes is also a worldwide supplier of pharmaceutical-grade, bioabsorbable polymers. We are well positioned for growth with several product candidates advancing in clinical trials, a group of strong corporate partners, a commitment to scientific and manufacturing excellence, and financial stability. If you are ready to join our challenging, team-oriented environment and are interested in the opportunities below, contact us.

Development Scientist

We are seeking a Scientist with a Ph.D. in Industrial Pharmaceutics, Chemistry or a closely related field. Providing strong technical leadership and interfacing effectively with business partners, you will be responsible for project planning and management, design and execution of formulations, and process development projects. The successful candidate would possess knowledge of formulations, process development, analytical techniques, experimental design, polymer science and parenteral manufacturing. Comprehensive experience in the pharmaceutical industry developing controlled release dosage forms is preferred.

Analytical Development Scientist

We are seeking an Analytical Development Scientist with a Ph.D. in Analytical Chemistry. The successful candidate would possess experience in developing methods using HPLC, GPC, GC, DSC, and dissolution apparatus as well as experience with controlled release dosage forms and polymer analysis. A minimum of 5 years' analytical laboratory experience in the pharmaceutical industry is also required.

Senior Analytical Chemist

We are seeking a Senior Analytical Chemist with pharmaceutical industry experience to validate and perform assays along with method development work. A Bachelor's degree in Chemistry and several years' experience in a GMP laboratory environment is required, including HPLC and GC analysis. Experience in polymer analysis, controlled release dosage forms, and experimental design a plus.

As a key contributor to our success you will be rewarded with a very competitive compensation package with stock options and excellent benefits. For immediate consideration, send your resume and cover letter, indicating position of interest, to: **Alkermes, Inc., Attn: Human Resources, 6960 Cornell Road, Cincinnati, OH 45242; Fax: (513) 489-8095.** We are an equal opportunity employer relying on the strength of a diverse work force.

Alkermes

ACADEMIC POSITIONS

INSTRUCTOR IN CHEMISTRY - The University of Southern Indiana invites applications for a non-tenure, renewable position for 1997-98 academic year to teach introductory chemistry lectures and laboratories. Master's degree in Chemistry required; teaching experience preferred. The University is committed to excellence in teaching, scholarship and professional activity, and service to the University and the community. Application deadline is February 28, 1998, but accepted until position is filled. Women and minorities are encouraged to apply. Submit letter of application; curriculum vitae; and name, address, and telephone number of three professional references to: **Dr. Marie Hankins, Chair, Chemistry Department, University of Southern Indiana, 8600 University Blvd., Evansville, IN 47712.** *AA/EOE*

ANALYTICAL/FORENSIC CHEMISTRY- The Department of Chemistry at Eastern Kentucky University is seeking applicants for a tenure track Asst. Prof. Position in analytical chemistry/forensic science to begin in Fall 1998. A Ph.D. and a commitment to undergraduate/masters level research and teaching are required. The succesful candidate will have teaching responsibilities in analytical chemistry and forensic science and will be expected to become actively involved in the undergraduate program in forensic science. Applicants should send a cover letter, curriculum vitae, transcripts, and three letters of reference by February 1, 1998 to: **Dr. Robert Fraas, Department of Chemistry, Eastern Kentucky University, Richmond, KY 40475-3124. http://www.nms.eku.edu/che/.** *AA/EOE*

THE INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY has an opening for a Postdoctoral Associate with a Ph.D. in environmental science/engineering or chemistry for modeling the performance of secondary treatment systems, and for developing online BOD/COD sensors. Applicants should submit a cover letter, resume, and three professional references to **Human Resources Manager, 500 10th Street, Atlanta, GA 30318,** or fax to **(404)894-5302** or e-mail to **pat.hughes@ipst.edu.**

ACADEMIC POSITIONS

ASSISTANT PROFESSOR ANALYTICAL/PHYSICAL CHEMISTRY

The Department of Chemistry at Kennesaw State University invites applications for a tenure-track position starting August 1998. Candidates must have an earned doctorate, preferably in analytical/physical chemistry with experience in computational modeling of environmental systems. The ability to teach instrumental analysis is a plus. The successful candidate will be expected to develop an excellent teaching program, a research program involving undergraduates and collaborative interactions with other faculty. Located in northwest Metropolitan Atlanta, Kennesaw State University enrolls 13,000 students. The Department of Chemistry has nine full-time faculty, a lab coordinator and a computer systems administrator. One hundred majors are enrolled in the department's ACS accredited B.S. degree program. While applications will be accepted until the position is filled, to guarantee consideration, send by February 15, 1998, a letter of interest, a curriculum vitae, graduate transcripts, and statement of teaching philosophy and research interests along with three letters of recommendation to **Dr. Leon Combs, Chair, Department of Chemistry, Kennesaw State University, 1000 Chastain Rd, Kennesaw, GA 30144-5591.** *KSU has established a notable record for inclusion of minorities and women and strongly encourages applications from both groups.*

POSTDOCTORAL POSITION IN ORGANIC CHEMISTRY: Position available to interact within interdisciplinary group of scientists involved in biomaterials research and tissue engineering. PhD in synthetic organic chemistry required for project focused on the synthesis of glycomonomers and polymerizable lipid conjugates. Experience with oligosaccharide synthesis desirable. Funded by NIH. Send CV and names of 3 references to: **Dr. Elliot L. Chaikof, Emory University, 1639 Pierce Drive, 5105 WMB, Atlanta, GA 30322. Fax (404)727-3660. E-mail echaikof@surgery.eushc.org.** *Emory University is An Affirmative Action Equal Opportunity Employer.*

ACADEMIC POSITIONS

MAYO CLINIC

The computer-aided molecular design (CAMD) lab of the Mayo Cancer Center/Pharmacology Department at Mayo Clinic Rochester seeks a research fellow with a PhD in computational chemistry, organic chemistry or related discipline to conduct design and computational screening of enzyme inhibitors.

The Mayo Clinic, with a research budget in excess of $130 million per year, provides an outstanding environment for the conduct of basic research in molecular medicine. The CAMD Lab has records of developing biologically active ligands with real world impact (e.g., we developed the highly potent and selective, low-cost bis-THA AChE inhibitor, which was reported by C & E News, News of the Week Section, September 30, 1996, and has been brought to commerical market by RBI/Sigma.) Resources include: NMR, mass spectrometry, fluorescence, research computing and other core facilities; the state-of-the-art synthetic equipment; Origin 2000 (8xR10K, 2Gb memory and 72Gb disk), 3 Origin 200 (6xR10K, 896Mb memory and 13.5Gb disk) and Octane (2xR10K, 128Mb and 4Gb disk) and three shared Power Challenge servers. Salary and benefits are competitive. Applicants contact:

Yuan-Ping Pang, Ph.D.
Department of Pharmacology
Mayo Clinic
200 First Street SW
Rochester, MN 55905
pang@mayo.edu

Mayo Foundation is an affirmative action and equal opportunity employer and educator.

BIOCHEMISTRY. The Department of Chemistry and Biochemistry at Denison University invites applications for a tenure-track faculty position in biochemistry at the **Assistant Professor** level to begin in August 1998. Applications are sought from individuals with a strong commitment to teaching at the undergraduate level, a superior background in biochemistry, and the capacity to develop an active research program which involves undergraduates. Teaching responsibilities will include biochemistry, general chemistry, and other courses for the major or nonmajor consistent with the candidate's interest and background. Ability to participate in the organic chemistry sequence would strengthen the application. The department has excellent facilities, computer resources, and instrumentation for teaching and research in biochemistry and all areas of chemistry. Instrumentation is available for separations (GC/MS and other GC methods, HPLC, electrophoresis), spectroscopy (FT-NMR, FT-IR, UV-vis, fluorescence), and molecular modeling (SGI workstations), as well as surface microscopy, powder X-ray, and AA. Generous start-up funds and a junior faculty research leave program are in place. Applicants should have earned a Ph.D. Postdoctoral experience is desirable. Send a CV, transcripts, a statement of teaching philosophy and research plans, and three letters of recommendation to **Dr. Michael M. Fuson, Department of Chemistry and Biochemistry, Ebaugh Laboratories, Denison University, Granville, OH 43023.** Inquiries may be sent by e-mail to: fuson@denison.edu. Information about the university and department is available at the university's website; http://www.denison.edu. Our review of completed applications will begin February 2, 1998. *Denison University is an Affirmative Action/Equal Opportunity Employer. Women and people of color are especially encouraged to apply.*

RESEARCH CHEMIST

The Bio-Analytical Section of the American Health Foundation has an immediate opening for an analytical chemist with B.Sc. or M.Sc. degree with 0-3 years' research experience, preferably in analysis of trace organic compounds in biological specimens and environmental samples. The position requires some background in classical and instrumental analytical chemistry with a special emphasis on capillary GC, HPLC, and supercritical fluid extraction (SFE). Please send resume to: **Department MD, American Health Foundation, and 1 Dana Road, Valhalla, NY 10595.** *EEO/M/F/H/V/ADA*

ACADEMIC POSITIONS

ASSISTANT PROFESSOR/ORGANIC CHEMIST

The Department of Chemistry at Wright State University invites applications for a tenure-track position in Organic Chemistry at the assistant professor level with appointment to begin September 1998. The successful candidate will be expected to establish a vigorous research program capable of attracting extramural funding and demonstrate a commitment to teaching and conducting research with Undergraduage and Masters students. Although all areas of organic chemistry will be considered, applicants with research interests in materials (polymer) or environmental areas are particularly encouraged to apply. Teaching duties will include undergraduate and graduate organic chemistry courses with their requisite laboratories as well as general (freshman) chemistry. Ph.D. in Organic Chemistry is required. Must possess good written and verbal skills. Applicants should send a curriculum vitae, detailed summary of research plans, including specialized equipment needs and three letters of recommendation to **Dr. Daniel Ketcha, Department of Chemistry, Wright State University, Dayton, OH 45435.** For first consideration applications should be received by February 27, 1998. *AA/EEO Employer*

VISITING FELLOW PROGRAM
CHERRY L. EMERSON CENTER FOR SCIENTIFIC COMPUTATION
EMORY UNIVERSITY

The Emerson Center offers a Visting Fellow Program to people who have permanent positions in other institutions and would like to spend one month to one year in the Center using its SP2 mini-supercomputer and large workstation cluster to perform research in computational chemistry and physics. Travel expenses (and stipend for long term stay) are available. Collaboration with Emerson Center "subscribers" in chemistry and physics departments is encouraged. The application deadline for summer 98-summer 99 is February 1, 1998. However, an earlier contact is strongly recommended. For details please contact **Keiji Morokuma, Director, Cherry L. Emerson Center for Scientific Computation, 1515 Pierce Drive, Atlanta, Georgia 30322, Phone: (404) 727-2380, Fax: (404) 727-6586, Email: morokuma@emory.edu, or refer to our web site for more details: http://www.emerson.emory.edu/fellows/fellers.html.** *Emory is an equal opportunity/affirmative action employer.*

DARTMOUTH COLLEGE VISITING FACULTY. The Dartmouth Chemistry Department anticipates temporary sabbatical-replacement positions to teach general and/or physical and/or organic chemistry during the July 1998-June 1999 academic year. Must have Ph.D. and established teaching record. Research collaboration possible in 16-faculty department with active Ph.D. program. Salary commensurate with experience. Send resume and names of three references by March 1 to **Dr. John S. Winn, Chemistry Dept. Dartmouth College, 6128 Burke Lab, Hanover, NH 03755-3564.** *AA/EOE*

ANALYTICAL AND PHYSICAL: Applications are invited for two tenure-track Assistant Professor positions to begin Sept., 1998, in the Department of Chemistry at Central Washington University. Position responsibilities include: teaching introductory courses, upper division undergraduate and MS graduate courses in the area of expertise, establishing an undegraduate/MS graduate research program, and participating in university service activities. A Ph.D. in chemistry or related field is required by the start date. For application procedures, position description, qualifications and questions, e-mail: chemseek@cwu.edu; consult http://www.cwu.edu/~chemweb/chemhome.htm; or call the Chemistry Department at (509) 963-2811. Screening will begin on February 20, 1998 and continue until a candidate is selected. *Central Washington University, located in Ellensburg, WA, is an AA/EOE/Title IX Institution.*

TWO POSTDOCTORAL POSITIONS are available in protein chemistry or protein NMR. One position requires proven skills in PCR, protein expression and purification. The other requires experience with multiDimensional NMR. Minimum Salary $24,000 + benefits. Additional information: **http://heme.chem.wsu.edu. Contact James Satterlee, Chemistry Dept., Washington State University, Pullman, WA 99164-4630; email hemetcam@cosy.chem.wsu.edu; 509-335-8620**

ACADEMIC POSITIONS

COMPUTATIONAL/SIMULATION
POSTDOCTORAL/VISITING SCIENTISTS
POSITIONS AVAILABLE

Position 1: Conformational and Mechanistic Computational Biochemistry. Will focus on ab initio and/or density functional theory conformational analysis of intermediate size ligands and active site (protein) reaction mechanisms. Application oriented position: conformational analysis, forcefield parameter development, coordinate reaction pathway analysis. Also, come opportunity for protein-ligand molecular dynamics simulations and structure-function analysis towards protein redesign. **Position 2:** Protein and protein-ligand molecular dynamic simulations. Will focus on molecular dynamics simulations and some modeling of protein-ligand interactions. Application oriented position: uncover structure-function-dynamics relationships in order to redesign enzyme/catalytic antibody function. These are 1-year positions, but renewable with mutual consent. Candidates must have a strong publication record and be highly motivated. Positions are available starting March/April 1998, but will wait for exceptional candidates. Send resume, three reprints, and email address of three professional references to **Dr. Rick L. Ornstein, Pacific Northwest National Laboratory, Mailstop K1-83, Richland, WA 99352, fax: 509-375-6904, email: rl_ornstein@pnl.gov**

THE DEPARTMENT OF CHEMISTRY & BIOCHEMISTRY of Cal Poly, San Luis Obispo, CA 93407, invites applications for full-time lecturers for the 1998-1999 academic year. Our lecturers teach general chemistry and service courses; efforts are made to offer teaching opportunities in your area of specialization. Ph.D. required at time of hiring. Salary: $37,956 - $42,612. Send letter of application with reference to recruitment number 83040, resume, statement of professional goals, and if available, evidence of successful teaching to **Dr. Albert C. Censullo, Chair. Three letters of recommendation should be supplied directly by references. All application materials must be postmarked by February 24, 1998.** *AA/EEO.*

UNIVERSITY OF WISCONSIN-STEVENS POINT

Tenure-track assistant professor position for Fall, 1998 in an 18-member, ACS approved Department in a predominantly undergraduate institution. Position is in organic chemistry, in an area of specializtion that complements the current faculty. Applicants with organometallic interests are especially encouraged to apply. Ph.D. required; must be completed by September, 1998. In addition to courses in organic chemistry, teach general chemistry as needs require. Applicant must show promise of excellence in undergraduate teaching and research. Send resume, copy of transcripts, and separate statement of teaching philosophy and professional interests. Applicants should also arrange to have three letters of reference sent to: **Dr. John Droske, Chair, Faculty Search, Department of Chemistry, UW-Stevens Point, Stevens Point, WI 54481.** Screening of applications will begin on February 10, 1998, and continue until position is filled. *UWSP is an Affirmative Action/Equal Employment employer.*

SENIOR LEVEL FACULTY POSITION: The Department of Chemistry at North Carolina Central University invites applications for a tenure track/tenured faculty position in any area of chemistry with a starting date of January or summer 1998. NCCU is located in the Research Triangle region of North Carolina. The six-member department is ACS-approved, offers B.S. and M.S. degrees, and is well equipped with modern instrumentation. Candidates must have the background, ability and motivation to maintain a vigorous, competitive research program and to excel as an educator. A Ph.D. is required, and previous administrative experience is desirable. Salary and rank will be commensurate with experience. Applications should include a detailed vita, research plans, statement of administrative philosophy, and three letters of recommendation. Forward all application materials to **Dean B. D. Johnson, College of Arts and Sciences, North Carolina Central University, Durham, NC 27707.** *NCCU is an Affirmative Action/Equal Opportunity Employer.*

ACADEMIC POSITIONS

THE DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY at Miami University seeks an individual at the M.S. level or higher with experience in mass spectrometry to serve as an instrumentation specialist for the mass spectrometry facility at Miami with possible additional duties in the NMR facility. Duties will include maintenance, training, sample analysis, and methods development for the Department's MALDI-TOF/MS and LC/MS. Qualified persons should submit their vitae and arrange to have two letters of recommendation sent to **Michael Novak, Chair, Department of Chemistry and Biochemistry, Miami University, Oxford, OH 45056.** This position will filled in the early spring of 1998. *Because Miami University is an Equal Opportunity/Affirmative Action employer, women and minorities are particularly encouraged to apply.*

SITUATIONS WANTED
(ACS Members)

TO ANSWER BOX NUMBER ADS:

Address separate envelopes for each reply to:

Box Number (As indicated)

c/o ACS

1155 16th St., N.W., Washington, D.C. 20036

ANALYTICAL

PH.D. ANALYTICAL CHEMIST: Experience with FT-Raman, FT-IR, NIR, GC/FT-IR, UV/Visible, AAS, GC, DSC. Expertise in material characterization, method development, data analysis, experimental design, and problem solving. Will relocate. **Box 400-B-1**

ANALYTICAL/CLINICAL CHEMIST, PH.D.: 20+ years experience hands-on technical management of clinical laboratory. Instrumentation background includes UV-VIS, IR, AA, DSC, automated analyzers, recent HPLC training. Available immediately. Call A. Tursi, (609) 346-4932. **Box 401-B-1**

CHEMICAL ENGINEERING

CHEMICAL ENGINEER PH.D./POLYMER SCIENCE M. S.: seeking polymer process-product R&D management position. Coating, drying, polymerization processes; coatings, resins, biomedical product scale-ups, vinyls, acrylics, SBR, fluoropolys, blends. Laboratory, pilot plant supervision. **(412) 367-7696**

PH.D. CHE.: 3 years industrial experience: Chemical plant design/engineering - concept to commissioning, and process development. Strengths: R&D, design of experiments, process control, data acquisition and control systems, modeling, simulation (ASPEN). Excellent computer skills, available immediately. Contact: Ramani Reddy (330) 434-7238. **Box 407-B-1**

INORGANIC

INORGANIC CHEMIST, PH.D.: highly motivated and creative, extensive research experience in main-group, fluorine (inorganic and organic), organometallic chemistry, 2 years postdoctoral, fluent in German and English, Permanent Resident, available immediately, will relocate. Phone/Fax: (616) 245-2139. **Box 402-B-1**

INORGANIC/ORGANOMETALLIC, PH.D., (1975): Seeks industrial position. Clinical industrial and analytical laboratory experience. Plant support, supervisory and communication skills. OSHA/EPA compliance for a Pulp & Paper mill. Community College, Adjunct Faculty. Box 5595, Cleveland, TN 37320-5595.

SITUATIONS WANTED
(ACS Members)

ORGANIC

PH.D. ORGANIC CHEMIST: Experienced in process development, analytical and physical chemistry. Over 10 years industrial experience. Excellent problem solver. Strong electronic and computer skills. Email: sgrecher@juno.com or phone (804) 379-8665. **Box 403-B-1**

ORGANIC/ORGANOMETALLIC CHEMIST: Postdoctoral, Ph.D., publication, patent in heterocyclic, hydroquinone-amine, alkyne, Si chemistry, Pd-Cu catalysis, multistep, air-moisture sensitive reactions. Skills: Schlenk techniques, TLC, flash column chromatography, NMR, IR, UV-Vis, MS. X-ray crystallography, computer (Microsoft Windows, MS-DOS). **Box 404-B-1**

ORGANIC/MEDICINAL PH.D.: 12 yrs. biotech & academic experience in multistep organic synthesis and drug discovery. Background includes heterocycles, antivirals, immunomodulators, herbicides, fungicides, anti-neoplastic and neurological agents. FT-NMR, FT-IR, UV, HPLC, Flash Chromatography. Strong computer skills. S. Giandinoto, 8306 Brittany Dr., Wayne, NJ 07470. (973) 628-1271.

SYNTHETIC ORGANIC/MED/PHARM CHEMIST, PH.D: postdoctoral, multistep synthesis, method development, radiolabeled synthesis, carbohydrate, nucleosides, fluorine chemistry. Proficient in chromatography, isolation, purification and structural determination. Supervisory capability. Strong computer skills. Seeking industrial position. Will relocate. Milton Perlmutter, 1015 Gayley Avenue, #1260, Los Angeles, CA 90024-3424, (310) 557-1403 (Phone & Fax); email mmp215@msn.com.

RESEARCH CHEMIST, PH.D. (90): Postdoctoral, industrial experiences. Multistep syntheses, heterocycles, antibiotics, amino acids, peptides, conductors, steroids, natural products, electronics, R&D, SMT, BGA process, soldering. Multilingual. **Box 408-B-1**

COMBINATORIAL CHEMISTRY, DIRECTOR (PH.D.): will establish and run combichem lab and add value to your drug discovery program. Energetic, visionary, and experienced (4 plus years in industry) in solid and liquid phase chemistries, automation, and process development. Seeking position in SF Bay Area. **Box 305-A-1**

PHYSICAL

DISABLED PHYSICAL/MATERIALS CHEMIST, M.S.+: Seeking research or management position, academic setting preferred. Skills: consulting, colloid-emulsion, EPR, transition metals, microbiology reactions, X-ray diffractions, solid state, and structure-properties, and grant writing. R. Joseph Barham, P.O. Box 207, Glen Aubrey, NY 13777, (607) 724-3596.

PH.D. PHYSICAL CHEMIST: 10+ years experience in fuel combustion and environmental remediation processes; skills: computer modeling, technical writing, communication; GC, lasers/lamps, flow/static reactors operation and designing. email: suresh.k.gulati@worldnet.att.net or call (609) 799-3769. **Box 405-B-1**

PHYSICAL/MATERIALS/EXPERIMENTAL CHEMIST, PH.D.: Seeking position in R&D materials/chemical processes, experienced in solid/solution crystallization, dissolution, particle characterization, H.T. melts and aqueous solutions. Solid separation/purification, analytical methods. Will relocate. G. Gardner, 47 W. Spring St., Buffalo, NY 14221. (716) 634-8514; email: CHENGLG@hotmail.com.

SITUATIONS WANTED
(ACS Members)

PHYSICAL CHEMIST, PH.D./ MBA, Certified Fire & Explosion Investigator. Specialize in chemical accident reconstruction, chemical safety, hazardous chemicals, aerosols, surfactants, foam, chemical-related OSHA, EPA, & DOT regulations, metallurgy, failure analysis, and corrosion. **520-749-0600**

PHYSICAL/MATERIALS CHEMIST, PH.D: Seeking position in R&D materials/chemical processes, experienced in solid/solution crystallization, dissolution, particle characterization, H.T. melts and aqueous solutions. Solid separation/purification, analytical methods. Will relocate. **G. Gardner, 47 W. Spring St., Buffalo, N.Y. 14221. (716) 634-8514.**

POLYMER

RESEARCH CHEMIST: Over 20 years of experience in research and product development in finishing, coating and wet processing textile fabrics with M.S. in Textile Chemistry/Chemistry is seeking position in the Southeast. **Box 406-B-1**

OTHER

BUSINESS-ORIENTED TECHNOLOGY MANAGER: Ph.D. (ChE) MBA, 20 years of experience in managing technologies and professionals for product/process/commercialization for plastics/healthcare packaging, PSAs adhesives/coatings, foods, elastomers, and specialty polymers/chemicals. Write or call (847) 680-7890. **Box 410-B-1**

TECHNICAL SALES/MARKETING/DISTRIBUTORSHIP: position desired in chemical/pharmaceutical company who are going to market their products in india. Strong sales background in chemicals. Can manage sales independently in India. Fluent Indian/English languages. Can travel extensively. Call Mr. Kewalnain Sachdev, Tel/Fax: (815) 637-6239. **Box 409-B-1**

M.S. BIOCHEMISTRY: Analytical, HPLC, FPLC, UV/VIS, GLP, GMP, ISO 9001. Management/interpersonal skills: prioritization, sales/marketing, patent licensing/technology transfer, troubleshooting, training and development. Ready for general assignment. Proficient in DOS, Win3.1, Win95, OS/2, MS Office, Lotus Notes. **Box 411-B-1**

CURRENT TESTIMONIALS BACK SUCCESSES: Industrial/institutional cleaning and maintenance products, surfactants, solvents, emulsion polymers. OFFERING: Cost-effective, environmentally friendly, workplace safe formulations meeting VOC limits, MSDS assistance, help integrating acquisition's products. F/T, P/T, contract projects. Dr. Bruce Harris, 801 E. Spring Valley Rd., Richardson, TX 75081. (972) 669-3289.

CONSULTANT

PHARMACEUTICAL STABILITY ANALYSIS: Proficient in all analytical concepts necessary to interpret analytical data. Plan and direct all analytical activities including developing and utilization of state of the art analytical technologies. Contact: Milton Elefant, 22 Mohawk Drive, Livingston, NJ 07039.

CHEMICAL & COATINGS PLANT MANAGEMENT CONSULTANT: 38 years manufacturing experience Chemicals, Coatings, Resins, Pigments, Personal Care Products and Aerosols. Available as Expert Forensic Witness. Jim Gadwood, 590 Pheasant Ridge Dr., Lake Zurich, IL 60047. Telephone (847) 438-0528.

COATING AND DRYING: Practical help in coating (especially slot and slide coatings), coating die design, drying of coated webs, and statistical process control. Co-edited "Modern Coating and Drying Technology". Edgar B. Gutoff, Sc.D., P.E., Phone/Fax: (617) 734-7081. **Box 412-B-1**

SITUATIONS WANTED
(ACS Members)

MICROENCAPSULATION CONSULTANT: Feasibility studies. R&D. Track record of many patents. Coat microorganisms, inorganics, organics, liquids, solids. Taste masking, controlled release, isolation of reactive ingredients. Former Merck R&D. Lewis D. Morse, 307 S. Dithridge St, #705, Pittsburgh, PA 15213. (412) 621-4066.

POLYURETHANE CONSULTANT: twenty-eight years of R&D/supervisory experience in the area of polyurethane chemicals (TDI, MDI, polyols) and monomers for engineering thermoplastics. Capable of working with small research groups in solving synthesis and process related problems. (203) 272-9159; e-mail: vraod@aol.com. **Box 413-B-1**

ADVISORY/WITNESS SERVICES: Innovation, utilization of hazardous products/processes. Compliance, litigation problems; defect/liability minimization. Warfare agents, radionuclides, nuclear isomers, carboxylates, MOCVD imaging, inks/toners, photoplates, phototemplates, pulp/paper, photolithography, photogravure, photopolymers, photomaterials, polysaccharides, oxyanionates. Dr. Jack J. Bulloff, FAAAS, FAIC, 8140 Township Line Road, Suite 5220, Indianapolis, IN 46260-5832. Phone: (317) 824-0014.

POLYMER CONSULTANT, PH.D: Polymer/organic chemistry. Experience in industrial management, research, college teaching, and consulting. Health care products, plastics, water soluble polymers, coatings, and adhesives. **Box 414-B-1**

EPOXY CONSULTING

Dr. J.C. Spitsbergen, 201/848-1444, 696 Knollwood Rd., Franklin Lakes, NJ 07417. Formulation database.

LAB SAFETY audits, inspections, program development, regulatory compliance, and training. **Kaufman & Associates 508-647-0900 JAKSafety@aol.com**

RETIRED

PESTICIDE PROCESSES: Bargain price for more than 100 reports which have copies of key patents and technical data. I have had both lab and production experience. Illness requires closeout. Dr. C. W. Huffman, 1141 Heatherfield, Glenview, IL 60025.

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This section includes: CHEMICALS EXCHANGE—Chemicals, Resins, Gums, Oils, Waxes, Pigments, etc.: EQUIPMENT MART—New and Used Equipment, Instruments; Facilities for plant and Laboratory: TECHNICAL SERVICES—Consultants; Engineering, Testing, Professional Services. *Advertising Rates:* Space rate is $480 per inch. Lower rates available on contract basis. An "inch" advertisement measures 7/8" deep on one column. Additional space in even lineal inch units. Maximum space—4" per Directory per issue. Set ads due 21 days in advance of publications; plated ads, 17 days. Centcom Ltd., 676 East Swedesford Road, Suite 202, Wayne, PA 19087-1612 Matt McCloskey 610-964-8061.

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DIRECTORIES

'Best of Newscripts' Reflects Changing Times

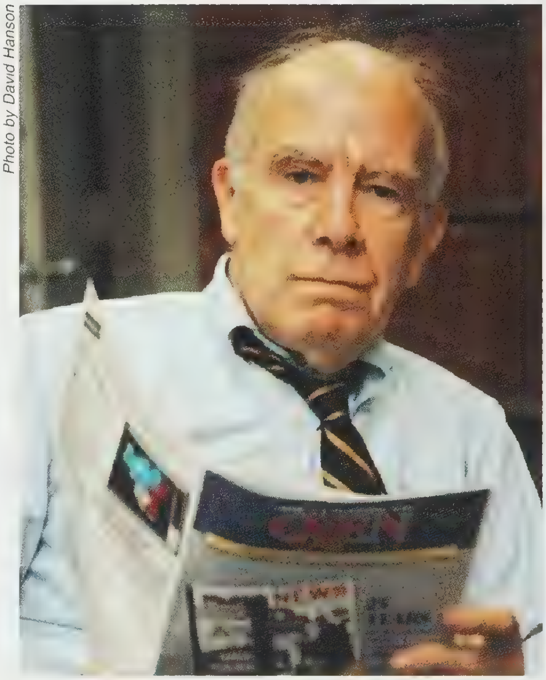

Photo by David Hanson

***Editor's Note:** Newscripts does not go back for a full 75 years. But it is one of the longest running editorial features in* Chemical & Engineering News. *It first appeared in its current form on the last editorial page of the July 10, 1943, issue. It has appeared there in every issue since, without fail.*

Partly because some people tend to take an initial browse through a magazine from back to front, Newscripts over the years has maintained a substantial and loyal readership. But a far bigger contributor to the feature's generally high reader acceptance has been the singular, if somewhat irreverent views, of the world in general—and the chemical scene in particular—of Kenneth M. Reese.

Reese has written Newscripts for the past 30 years. He was C&EN managing editor from 1962 to 1967 and he is a former Navy flier, among other things. The following is his selection of the best of nearly 55 years of Newscripts.

K. M. Reese
C&EN Washington

Newscripts has been called many things, not all of them nice, during its long history. An earlier memoir outlined the column's history and principal architects (C&EN, July 12, 1993, page 30). Here we focus more on content, quoted directly with interpretive remarks.

NEWS-Scripts

The editorial policy of Newscripts, if any, has tended traditionally to favor the chemical over the nonchemical, the scientific over the nonscientific, the abnormal over the normal. Still, the column has evolved subtly over the years in response to social trends and irate readers. In aid of conveying a sense of this evolution, the selections quoted here appear chronologically by date of issue.

Poetry, written or plagiarized by readers, has long been a staple of Newscripts. A precursor column, Emanations, carried this verse about heavy water (D_2O) when it was still a novelty:

"Kind Sir, please tell me truly
Of this water that is newly
Will it lather?

NEWS-SCRIPTS

"If I use pure Ivory soap
In this liquid isotope
Will it lather?

"Or should I prefer Lifebuoy
As in the ads they sometimes doey
Will it lather?" (Nov. 20, 1938)

The war years

World War II would erupt less than a year later, and the War Production Board of that period stirred endless comment by its often necessary but sometimes picayune intrusions into people's lives. The board once decreed "that belt loops may be placed on slacks, shorts, and ski pants (except for male children).

"After watching [a] three-year-old in these days of nonelastic elastic in underpants, we are convinced the system of 'a grab and a hitch' is as much a first law of nature as self preservation. He does it like a veteran. We face the edict of no belt loops for male children calmly and unafraid." (July 10, 1944)

Language lessons

Once upon a time, the requirements for a degree in chemistry included reasonable competence in a foreign language. A jocular essay in fractured German in those days could be counted on to convulse a chemical audience. Two such yarns that appeared during 1952 were "Der Franklin und sein Keit" (April 28) and "Der Volta und seine Peils" (June 2). Language skills were declining even then, however, and Newscripts noted only five years later that "To keep up with rapid advances in technology . . . scientists have had to develop new terms—and also ways of translating these terms into foreign languages. An up-to-date English-German glossary . . . includes:

–NEWS-SCRIPTS–

• "Guidance system: Das Schteerenwerke.

• "Preset guidance: Das senden offen mit ein pattenbacker und finger gekrossen Schteerenwerke.

• "Warhead: Das Laudenboomer.

• "Nuclear warhead: Das eargeschplitten Laudenboomer.

• "Project engineer: Das Schwettenoudter." (Sept. 9, 1957)

Field correspondence

In the European vein, the parade of operatives who have personned the ACS editorial post in London, established in 1950, have spent most of their time rushing around the British Isles and the Continent covering the chemical news. On occasion, however, they have found time to touch on the local color:

"They (motor scooters) aren't considered too undignified over here. . . . Everybody in Paris rides one with a girl on the back. In London this week I saw a type with a bowler hat and striped pants riding by with his umbrella stuck under the seat crosswise. . . . I haven't received anything from the U.S. for three weeks except a trick package of peanut brittle. It ejected three huge artificial snakes when I opened it." (July 7, 1958)

C&EN's field editors have by no means confined their abstruse commentary to foreign climes. The chap who once covered the 13 southeastern states (a.k.a. the Dixie Division) confided one day that he had called on chemical operations in five cities on successive days and had slept every night in the Robert E. Lee Hotel. He had noticed also "in *The Charlotte Observer* . . . that Elgin National Watch had broken ground at Blaney, S.C., for a pilot plant.

" 'What do you suppose they're going to make?' he asked himself. 'Little teeny watches?' " (Sept. 17, 1962)

Tobacco redux

The behavioral police have lately been emitting reams of virtuous remarks about cigarettes, but Newscripts has consistently been ahead of the curve on that topic. Long ago, the column reminded the tobacco industry that it "should be thankful that the anticigarette faction does not include James I of England, who was the leader of an antinicotine movement there in the 17th century. That monarch, who evidently learned invective from experts, once described smoking in his brusque but winning way as 'a custome lothsome to the eye, hatefull to the Nose, harmfull to the braine, dangerous to the Lungs, and in the blacke stinking fume thereof, neerest resembling the horrible Stigian smoke of the pit that is bottomelesse.' " (July 8, 1963)

Horse medicine

Speaking of kings, their sport turned up in Newscripts on the occasion of the 94th Kentucky Derby. Dancer's Image, the winner, was disqualified when traces of the analgesic and anti-inflammatory drug Butazolidin (phenylbutazone) were found after the race in the urine of the big gray son of Native Dancer. The Kentucky State Racing Commission was holding secret hearings on the matter at press time, and Newscripts could learn little by telephone. Expert Ian Paton, however, "did opine that the basic question is 'What is the proper treatment for a racehorse?'

"Q. Could you enlarge on that comment about proper treatment?

"A. Well, for example, is immersion in ice water proper? Baseball pitchers do it all the time, as you know.

"Q. Would that be only the legs?

"A. In the case of horses, yes." (May 20, 1968)

Historical oddities

Because Newscripts' readers span more than one generation, the odd historical snapshot, whether chemical or not, seems appropriate and instructive. One such account began "deep in the interior of Mexico, where a couple from Texas found a little Indian boy alone and crying. They took him home and raised him as their son. The boy enlisted in the U.S. Air Force during the Korean War . . . and became a fearless fighter pilot. He originated a brilliant . . . combat maneuver that became known as the Miracle Whip. On his first day of combat, using this tactic, [he] shot down five enemy planes, thus becoming the first Mayan ace." (Feb. 9, 1970)

Gender police

The gender wars have been afoot for some years now, in the chemical community and elsewhere, and Newscripts knows a good bandwagon when it sees one. A pertinent trendy item:

"Many readers will know by now that the Bureau of the Census has revised its Occupational Classification System to help eliminate the concept of 'men's jobs' and 'women's jobs.' Sample changes are as follows:

Old	New
Salesmen	Sales workers
Office boys	Office helpers
Airline stewardesses	Flight attendants
Policemen	Police

"Since the topic has come up, this department has long bridled at the custom of calling ships 'she' or 'her.' How much better it would be the other way around:

"I must down to the seas again,
to the lonely sea and the sky,
And all I ask is a tall ship
and a star to steer him by."
(Feb. 4, 1974)

Pitfalls of progress

Science and technology are marvelous, but Newscripts has deduced over the years that new developments do not always merit the late Pollyanna's rosy outlook. Caution, or even cynicism, is the safer editorial stance. Such as:

"The American National Standards Institute has come out with two standards 'to help make sure that automobile and truck mechanics . . . acquire the necessary degree of competence.' This should be cheering news, but what it suggests, somehow, is that all the factory-trained mechanics will suddenly start making identical mistakes." (July 23, 1973)

Poetry at dusk

Chicago's Loco Chemical Co. and its chief executive officer, Sir J. Conrad Bleet, have turned up now and then in Newscripts on the strength of their cutting-edge thought and activities. On one notable occasion, Sir Conrad was "enshrined in a poem, 'The Love Song of J. Conrad Bleet.' The work . . . opens with the lines:

'Let us go then, you and I,
When the evening is spread out
around the sky

News-scripts NEWS SCRIPTS NEWS Scripts

Like a Grignard etherized inside a flask;
Let us go, through certain half-deserted labs.'

"This impassioned plea, forged in the holocaust of a mighty love, drove a palpitating maid, one Lily Astolat, to pen a 'Response to the Love Song of J. Conrad Bleet':

'Tyger! Tyger! burning bright—
Take me to your lab tonight.
You have lit my bunsen burner
Made my day a bit more schöner.
Aliquot me—yea, distill me!
I'm your beaker! C'mon, fill me!
Wee sleekit, cowrin' tim'rous Beastie,
You've put a panic in my breastie!'"
(Feb. 28. 1977)

Baking tips

Pulling the plug on the sea of technological applesauce that inundates us nowadays is almost irresistible, although sometimes morally equivalent to shooting a sitting bird. Still, a local person, "who was reading a cookie package found that the ingredients included 'evaporated apples.' 'After they evaporate the apples,' she asks, 'how do they get them into the cookies?' Who knows? One is reminded of the late Fred Allen, who once wondered aloud on his radio show how the condensed milk industry got the cows to sit on those little cans." (May 8, 1978)

Animal welfare

Ever since being charged unexpectedly with being antibat, Newscripts has taken care to keep readers posted on events in animal welfare. They occur sometimes in odd circumstances: "A legislator in Connecticut has introduced a bill that would ban the throwing of instant rice at weddings, according to the National Wildlife Federation. [She] claims that the rice kills the birds that eat it by absorbing moisture, causing severe bloating. She wants well-wishers to throw birdseed instead." (Aug. 26, 1985)

Chlorine therapy

Another instructive historical snapshot surfaced during C&EN's first year, in the newsletter of the Compressed Gas Manufacturers Association. The American Chemical Society, the newsletter revealed, had announced (in 1923) "that 900 tests were recently made on 300 students and members of the faculty of the University of Arkansas, who for five minutes daily inhaled air containing a small quantity of chlorine. A decrease in influenza cases from 133 per thousand to 44 per thousand was the result. This confirms the results of other investigations made along the same lines, all of which prove that chlorine is a successful preventive of influenza." (Feb. 2, 1987)

Lawyer bashing

Modern social trends include, of course, lawyer bashing, and readers consistently have kept Newscripts au courant. One reader suggested "that lawyers should replace white mice in toxicology experiments. . . . there are more lawyers than white mice and also this development would solve animal rights problems . . . the main problem would probably [be] trying to extrapolate the results from lawyers to human beings." (March 23, 1987)

Doublespeak

Silly syntax is a fruitful target for editors unconcerned about the glass-house adage (that is, if you live in one, don't throw stones). In this arena, a handy source has been the *Quarterly Review of Doublespeak*. In one issue, *QRD* took a shot "at a noted university's course catalog, where it says that Nursing II 'focuses on the care of clients throughout the life cycle who have basic alternations in health status. Stresses a multidimensional approach and encompasses . . . the amelioration of the health status of the client. The restoration of health a major focus.'" (Oct. 19, 1987)

Lottery fever

One advantage of longevity is getting to see everything more than once, not that it does much good. A notable example is state-sponsored gambling, which consumed some $40 billion in 37 states in this country in 1996. Newscripts characteristically was on top of the trend:

"Lotteries have spread rapidly during the past quarter-century, as you might expect of such a dandy way for governments to raise money without raising taxes. They boast a long tradition . . .

"An authorized lottery was employed in the year 1612 to help finance the Virginia Company's settlement of Jamestown . . .

"In 1832, the eight state lotteries in operation grossed more than $53 million, or 3% of the national income. . . . Fraud and dishonesty began to take their toll, and by 1860 only Delaware, Missouri, and Kentucky were operating lotteries. With the end of the Civil War the lottery rose again in the form of the Louisiana Lottery, which enjoyed a 25-year monopoly in this country. . . . [It] evidently was as crooked as a dog's hind leg, however. Congress, bowing to the public outcry, banned interstate transportation of lottery tickets in 1890 and banned lotteries altogether in 1894.

"So matters rested until 1964 and the birth of the New Hampshire Sweepstakes. In between, people played bingo." (May 28, 1990)

Stress management

A take-the-fun-out-of-the-holidays movement has emerged in recent years, courtesy, apparently, of the community of shrinks. The putative problem appears to be stress. One would expect to find further data in the "Diagnostic and Statistical Manual of Mental Disorders" (DSM IV, American Psychiatric Association, Washington, D.C., 1995). This manual, however, although a barrel of laughs, does not identify the holiday syndrome in terms comprehensible to the layperson. For this purpose, Newscripts resorted to a newsletter, *Taking Care*, which recommended avoiding "holiday health-sappers: not enough sleep, too much rich food, too much alcohol, and not enough exercise. Undoubtedly this plan has merit, but it sure doesn't leave much room for frivolity. . . .

"From . . . another antistress strategist comes the following tip: 'Any current problem will intensify under the stress of the holiday season. Problem solve now.'

"As the late Wolcott Gibbs once remarked in another context, 'Where it will all end, knows God!'" (Dec. 3, 1990)

And so it goes.

Newscripts Newscripts *NEWSCRIPTS* **NEWSCRIPTS**

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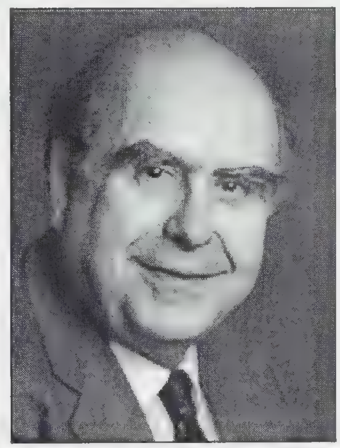
EDUCATION PUZZLER



Name this famous chemist who is not only the founder of one of the world's largest chemical supply companies (Sigma-Aldrich) but is also a world renowned collector of Dutch masterpieces.

For the answer to the puzzler, scroll to the bottom of this page.

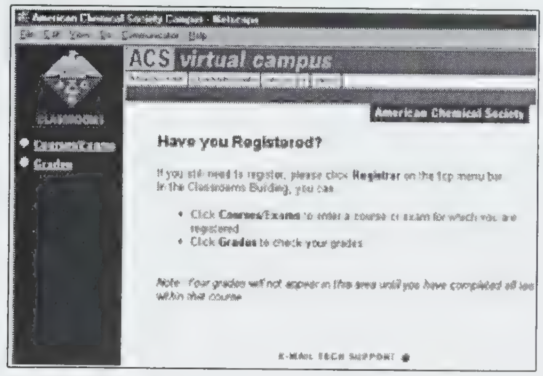
There are two committees with oversight responsibilities for a range of the ACS education programs. The Committee on Professional Training (CPT) addresses quality issues in post-secondary education especially through the ACS approval process for undergraduate chemistry programs. The Society Committee on Education (SOCED) oversees all other educational programs, materials, and services from kindergarten through to the continuing education of career chemists.

What's New!

The ACS Continuing Education Department Opens

Virtual Campus on the Internet

The American Chemical Society (ACS) Continuing Education Virtual Campus opens up this month at www.uol.com/acs. This new Web-based service provides greater access to quality continuing education programs for ACS members and others in the scientific community thanks to the worldwide accessibility of hte Internet 24 hours per day.



The first course offered on the campus is *Basic Statistical Analysis of Laboratory Data*, developed by two renowned ACS Short Course instructors, Stanley N. Deming and Stephen L. Morgan. The course is completely interactive with on-line exercises designed to help the student gauge his progress at every step of the way and the opportunity to participate in on-going discussion forums and interact with the instructors and other chemistry professionals who are taking the on-line course. A free preview of the first two modules of the course can be found at www.uol.com/acs.

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Education Puzzler! Answer: **Dr. Alfred Bader**

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Last updated September 1, 1998.

Local art dealer bids $14.6 million for paintings

Prices are second-highest for Rembrandt, Rubens

By Joel Dresang
of the Journal Sentinel staff

Milwaukee's Old Master was at it again Friday.

Alfred Bader, world-known art dealer, industrialist and chemist, plunked down $14.6 million for paintings of a man with a beard and a beheaded saint.

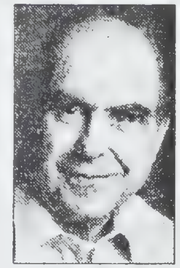
Bader bid the second-highest auction prices ever for a Rembrandt and a Rubens.

At Sotheby's Old Master auction in New York, he offered $9.1 million — more than twice the pre-sale estimate — for Rembrandt's "Portrait of a Bearded Man in a Red Coat."

And for Peter Paul Rubens' "The Head of John the Baptist Presented to Salome," Bader paid $5.5 million.

Sotheby's said Bader didn't say whether he planned to keep the paintings, sell them or donate them.

He is known to occasionally buy artwork at the request of a museum, then hang onto it until the museum can pay for it.



Bader

Bader, who's 72 and runs a small, by-appointment-only art gallery in the Astor Hotel, is recognized internationally as an authority on the works of great pre-18th-century European painters.

Bader and his wife, Isabel — who split their time between Milwaukee's upper east side and a house near London — also have prized Old Masters in their personal collection of some 200 works.

Bader's bids Friday for a Rembrandt and a Rubens are topped only by $10.5 million in 1986 for Rembrandt's "Girl Wearing Gold-Trimmed Cloak" and $6 million in 1980 for Rubens' "Samson and Delilah."

The Austrian-born Bader fled pre-Nazi Vienna as a teenager and eventually became a U.S citizen.

In 1951, he co-founded Aldrich Chemical Co., which today as Sigma Aldrich Corp. is still a major supplier of hard-to-find chemicals for research.

He stayed on at Sigma Aldrich as chairman emeritus until 1992.

Three years ago, he published an autobiography, "Adventures of a Chemist Collector."

The Associated Press contributed to this report.

Dear Marvin:

Could you please fax phone # of Neville ORGEL in Bnei Brak

He called about a painting, but left no number.

As always
Alfred

FAX MESSAGE

To: Dr. Alfred Bader
guest of Prof. Munk

From: Annabel Pilgerstorfer, Foreign Correspondent New York
Austria Presse Agentur, Vienna, Austria
Tel/Fax: 212 - 348 9257

Subject: URGENT: corrections article
Date: 02-04-1998
Pages: 3

Message:

Sehr geehrter Herr Doktor Bader,

anbei wie besprochen der Artikel mit der Bitte um etwaige Aenderungen, sollte fachlich etwas nicht korrekt sein. Sollte ich bis heute abend keine Nachricht von Ihnen bekommen, schicke ich die Meldung nach Wien.

Nochmals vielen Dank fuer Ihre Zeit und Ihre Hilfe - es war ein Vergnuegen, mit so einem interessanten Menschen sprechen zu duerfen.

Mit freundlichen Gruessen

A. Pilgerstorfer
Annabel Pilgerstorfer

Sie können ev. Korrekturen auch gerne faxen:
212 - 3489257

2 Korrekturen:

(1) Meine Mutter (geb. Gräfin SERENYI) war Katholikin (siehe Kapitel 1 meiner Biographie)

(2) Ich verliess Wien am 10. XII 1938, einen Monat nach der Kristallnacht.

Beste Grüße, in Eile
Alfred Bader

Kunst/Porträt/USA/Österreich

Rembrandt-Käufer: Selfmademan, Forscher und Philantroph mit Wiener Wurzeln
Utl.: Alfred Bader will Alte Meister weiterverkaufen - Erfolgsstory mit traurigen Beginn =

New York (APA) - Er ist ein anerkannter Chemiker und Forscher, ein überaus erfolgreicher Selfmade-Geschäftsmann und ein begeisterter Kunstliebhaber - und er ist gebürtiger Österreicher: Alfred Bader, der bei einer Sotheby´s-Auktion in New York vergangene Woche zwei Alte Meister um insgesamt umgerechnet 187,6 Millionen Schilling ersteigert hat. Er habe die Bilder zum Weiterverkauf erworben, meinte Bader am Mittwoch in einem Telefon-Interview mit der APA. Damit hat der heute in Milwaukee (Bundesstaat Wisconsin) lebende millionenschwere Geschäftsmann die New Yorker Galerie Otto Naumann Ltd. beauftragt. ****

Umgerechnet 117 Millionen Schilling war dem Kunstsammler und -händler Bader Rembrandt´s "Porträt eines bärtigen Mannes im roten Mantel" wert, 70,6 Millionen Schilling das Rubens-Gemälde "Der Kopf von Johannes dem Täufer, wie er Salome übergeben wird". Und doch: Er wolle der Bilder weiterverkaufen, sagte Bader. "Ich will ja nicht in einer millionenschweren Festung wohnen" - so die Erklärung des Kunstliebhabers, der in Milwaukee eine große Kunstsammlung besitzt.

Die Geschichte des überaus erfolgreichen Geschäftsmannes Bader, die er selbst auch in seiner 1995 erschienen Autobiographie "Adventures of a Chemist Collector" erzählt, liest sich wie ein modernes Märchen - allerdings mit einem traurigen und dramatischen Beginn. Der 1924 als Sohn jüdischer Eltern in Wien geborene Bader besuchte in Wien das Gymnasium in der Sperlgasse. "Doch am Tag nach der Reichskristallnacht mußte ich flüchten", erzählte Bader, der heute noch "jedes Jahr einmal" nach Wien zu seinen "vielen Freunden" zurückkehrt. Der damals Vierzehnjährige flüchtete 1938 - zehn Monate vor Kriegsausbruch - nach England. Von dort wurde er als "feindlicher Ausländer" nach Kanada deportiert und in einem Kriegsgefangenen-Lager interniert.

Nach seiner Entlassung im Jahre 1941 begann Bader an der Queen´s University in Kingston im kanadischen Ontario sein Studium der Technischen Chemie. Nach Abschluß des Studiums 1945 forschte der Chemiker an der Harvard University auf dem Gebiet der Organischen Chemie und schloß seine Forschungstätigkeit in Harvard 1950 mit dem Doktortitel ab. In der Folge arbeite Bader als Forscher für die Pittsburgh Plate Glass Company: Dort entwickelte und patentierte er 1954 eine Methode zur Erzeugung einer speziellen Bi-Phenolsäure, die das Unternehmen damals für umgerechnet knapp 13 Millionen Schilling verkaufte.

Als der junge Chemiker zu dieser Zeit Probleme bei der Beschaffung seltener organischer chemischer Grundstoffe für die Forschung hatte, gründete er seine eigene Firma, Aldrich Chemical Company, die sich unter ihm zu einem gewinnbringenden Unternehmen auf diesem Markt entwickelte. Parallel zu seiner Geschäftstätigkeit

publizierte Bader auch chemische Nachschlagwerke. In den frühen Siebziger Jahren schließlich verschmolz Baders Unternehmen mit der Biochemie-Company Sigma. In der Folge zog sich Bader wegen struktureller Umstellungen in der neuen Firma nach insgesamt vierzigjähriger Geschäftstätigkeit aus dem Unternehmen zurück.

Der Kunstliebhaber widmete sich fortan seiner neuen Karriere als Kunsthändler. Auf den Gebieten der Chemie, der Erziehung und jüdischer Interessen hat sich Bader als Philantroph einen Namen gemacht. Z.B. spendete er "seiner" Universität in Kanada als "Dankeschön" für sechs Millionen britische Pfund das englische Schloß Herstmonceux in Sussex, in dem sich das alte königliche Greenwich Observatorium befindet.
(Schluß) api

Center for Science Education teams UWM, Medical College

Milwaukee's public university and private medical school have teamed to create a new center to support science and mathematics education. The joint Center for Science Education will merge the programs and activities of the Medical College of Wisconsin's Center for Science Excellence with UWM's science and math community outreach programs in the College of Letters and Science.

UWM and the Medical College are launching new educational and community outreach initiatives under the banner of the center. The center is believed to be the first major collaborative effort between public and private educational institutions for the advancement of science education.

Among the programs and activities included in the new merged center are the Medical College's Mini-Medical School programs and its middle school hands-on laboratory series, as well as UWM's Science Bag and planetarium programs.

"The Center for Science Education is the long dreamed-of and greatly needed 'connect' that provides opportunities for students of all ages, teachers, and the public in general to experience science in everyday life," says L&S Dean Marshall Goodman.

"The Medical College and UWM share a commitment to raise the quality of science education in our state and to stir a passion in young students for the process of scientific discovery," adds T. Michael Bolger, president and CEO of the Medical College.

Jeffrey L. Osborn will serve as director of the new joint center. He was formerly the director of the Medical College's Center for Science Excellence, and continues as an associate professor of physiology there. Osborn will be assisted by four staff members located at both UWM and the Medical College.

"Both institutions bring significant strengths to this partnership," says Osborn. "It marries UWM's extensive urban-based educational resources and faculty with the Medical College's professional scientific base and orientation."

New programs to be created by the center include:

- Expanded children's programs at the planetarium.
- Transfer and expansion of the Medical College's middle school hands-on science laboratory program to UWM, where the outreach effort will be expanded to include field trip activities in physics, chemistry, biology, and the geosciences.
- Development of hands-on laboratories at the Medical College for advanced high school students. The laboratory experiences would build on high school biology and chemistry curricula by providing students with learning experiences in molecular biology and biochemistry, physiology, pharmacology, and microbiology.
- Expansion and development of summer science camps for gifted students in area middle and high schools.

The Center for Science Education is the second joint program of the Medical College and UWM. Since 1978, the two institutions have sponsored the Marine and Freshwater Biomedical Sciences Center.

Display charts Bader's career

Documents and other items tracing the career of chemist Alfred Bader have been put on display by the Chemistry Department.

Bader, a native of Vienna, co-founded Aldrich Chemical in a garage on Farwell Ave. in 1951. That firm, which is now known as Sigma-Aldrich, has grown into the world's largest supplier of fine research chemicals.

The exhibit includes some of the first Aldrich Chemical account ledgers, canceled checks and product catalogs, pictures of former employees and the firm's first building, a stock prospectus and certificate, chemical bottles and labels, and company annual reports.

It also includes reproductions of paintings from Bader's personal art collection, as well as a copy of his autobiography, *Memoirs of a Chemist Collector.*

The exhibit is free and available for viewing during the Chemistry Department's normal operating hours.

Bader's personal life has been as eventful as his scientific career. He fled to England at age 14, ten months before the outbreak of World War II. Although a Jewish refugee from Nazi Germany, he was interned in England in 1940 as a result of British wartime policy.

This mistake resulted in his transport, along with other designated "enemy aliens," to a Canadian prisoner of war camp.

After his release in 1941, he attended Queens University in Kingston, Ontario, to study chemistry. Shortly thereafter he received a fellowship to study chemistry at Harvard University, where he earned his Ph.D.

Web site features audio archive

WUWM's web page has been redesigned and now includes an audio archive. The archive allows users to access the best of WUWM's local productions.

Currently in the archives are Bob Bach's series on the rainforest, which was produced in cooperation with Rolf Johnson of the Milwaukee Public Museum; reports on Wisconsin's W-2 program; and a story about a woman who used her life savings to start a nursing home for poor people from Milwaukee's inner city.

A link is provided to a site where users can download the Real Audio software required to listen to the reports.

WUWM's web site also includes updated program information, a complete program schedule, and information on other station activities.

You can find WUWM Milwaukee Public Radio on the web at **http://www.uwm.edu/wuwm** and on the radio dial at 89.7 FM.

[illegible]

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University of UWM Wisconsin-Milwaukee

Alfred Bader Finds Art in Chemistry *and* Vice Versa

WRITTEN BY ELFRIEDA ABBE

A few years ago, Alfred Bader was on a quest to track down the unknown artist of an oil painting he owned. It depicts two men, seemingly a teacher and student, performing some sort of procedure in a chemistry lab. Bader, founder of Aldrich Chemical Company in Milwaukee, which later became the Sigma-Aldrich Corporation, wrote about his search in a professional publication, *Chemistry in Britain.*

He immediately recognized the procedure in the painting. "Why, I have done that reaction myself," he wrote.

"He's a Renaissance man . . . he has experience and knowledge far beyond the ordinary."

"Two yellow liquids are poured together and a blue pigment precipitates. It is the production of Prussian blue."

He investigated further and found that W.T. Brande, a self-taught chemist who lectured at the Royal Institution in London, and his student, Michael Faraday, demonstrated and lectured on Prussian blue synthesis in the late 1820s. Perhaps, Bader suggested, the teacher had commissioned an artist to depict him and his student.

The questions of who that artist was, when he painted the portrait, and the painting's connection to a similar work, "A Chemist's Laboratory" (1827), owned by the Museum of History and Science at the University of Oxford, were still unanswered when the piece was published, but the article itself offers some clues about the man who wrote it.

The article brings together two of Bader's lifelong interests — chemistry and art — and reveals his expertise in both areas. What comes through the most, however, is the relish and delight Bader takes in the process of unraveling a mystery. The reader begins to suspect that the articulate author — recognized worldwide as a chemist-writer-lecturer and as an art collector-dealer — is a detective at heart.

"I am never happier than when hunting for dirty old paintings that might be hidden treasures," he wrote in his autobiography, *Adventures of a Chemist Collector.*

While building his multimillion dollar chemical company, Bader traveled worldwide in search of rare research chemicals for his catalog. When poking around chemists' laboratories, he took every opportunity also to poke around dusty antique shops, galleries and auction houses for art works.

After leaving Sigma-Aldrich in 1992, Bader opened Alfred Bader Fine Arts in Milwaukee, where he now devotes much of his indefatigable energy to buying and selling art. The Milwaukee gallery features modestly priced works representing a variety of eras and styles, such as a lovely series of tempera paintings by contemporary Czech artist Jaromír Kosar. But the gallery specializes in Dutch masters, some of which Bader keeps in New York and London, where the market is stronger.

"I buy what I like and think I can sell," said Bader, who bought his first drawing when he was 10 and through the years has added many 17th century Dutch masters to his personal collection. His debut as an art dealer made quite a splash. He bought a Rembrandt painting of Johannes Uyttenbogaert for several million dollars at a Sotheby's auction, then resold it to the Rijksmuseum in Amsterdam, thus establishing a reputation as an astute art dealer that rivals his reputation as a chemist.

Sitting at his desk in the gallery, surrounded by art and piles of papers, he talked about his passions for art and chemistry. His deep-set eyes, hooded by shaggy brows, give him a kindly demeanor, but also the air of a keen observer who can quickly assess what's before him, whether it's a painting or a person.

A man of many interests, Bader spoke of his lifelong study of the Bible and Judaism; his pride in building Aldrich and the company's profitable merger with Sigma International in St. Louis to form Sigma-Aldrich; his love

Alfred and Isabel Bader in front of Herstmonceux Castle in England. They bought the castle for Queens University and it is now an international study center.

for his wife, Isabel; and an area of growing importance to them both, philanthropy.

His autobiography captures the breadth and depth of a full, colorful life that is an adventure story, a lesson in individual struggle and accomplishment, a love story and a spiritual quest all wrapped into one

"He's a Renaissance man," said Marshall Goodman, dean of the College of Letters and Science. "He has experience and knowledge far beyond the ordinary."

Bader grew up in Europe under the dark cloud of anti-semitism and war. In 1938, his paternal aunt, who raised him, secured a place for him on the first Kindertransport, which took 10,000 Jewish children to England. She stayed behind and later died in Theresienstadt, the Nazi concentration camp near Prague. "I was shaped by what happened to Mother (his aunt)," said Bader, now in his 70s.

In 1940, the British rounded up all German and Austrian males between the ages of 16 and 60, labeled them "enemy aliens" and sent them to POW camps in Canada. Later the authorities figured out that they were holding Jews who had fled the Nazis in Europe. Instead of being bitter, Bader looked upon his stay at the camp outside Montreal as "a great education," thanks to the camp school. Once released, he attended Queen's University just outside Montreal, where he received an M.S. in chemistry and then went on to Harvard for an M.A. and Ph.D. in chemistry.

Bader remains in demand as a writer and speaker with expertise in art, chemistry and the Bible. The couple travel yearly to the world's major art auctions and Bader continues to act as a consultant to small chemical companies

Alfred is busy enough for two or three people," said Isabel Bader, a stately woman with a direct gaze, who joined us for the interview

The profound events in his early life and the individual acts of kindness he received deeply touched Bader, giving him a strong moral compass, a sense of personal responsibility, a fighting spirit and a longing for spiritual knowledge that underlie his desire to help others.

The Baders' philanthropic endeavors — from setting up scholarships for chemistry and art students to helping the traumatized in Bosnia — take up much of the couple's time. They are particularly proud of the Herstmonceux Castle in Sussex, England, which they purchased for Queen's University and is now an international study center. At UWM, the couple established scholarships for students to study at the15th century castle. Isabel Bader generously contributed to the UWM New Directions scholarship fund for students returning to college.

When asked if he had a philosophy of giving, Bader vividly recalled the words his beloved "Mother" wrote him in every letter: "May you be blessed, and may you be a blessing."

What better way to honor her words than by helping people around the world.

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ALFRED BADER FINE ARTS

DR. ALFRED BADER

ESTABLISHED 1961

April 13, 1998

Mr. Bruce Wolmer
Editor in Chief
Art & Auction
440 Park Avenue South
14th floor
New York, NY 10016

Via: Certified Mail, Return Receipt Requested

Sir:

I have long enjoyed Souren Melikian's columns in *Art & Auction*, until I saw his comments about my purchases of a Rembrandt and a Rubens, on page 80 of your April issue. Mr. Melikian must have been tired or preoccupied when he previewed Sotheby's January 30 old master sale. Mr. Melikian's alleged that the Rembrandt "is so weak that a German scholar, judging its merit from a photograph, published it as the work of a pupil." Of course I know Professor Tümpel's doubts about the painting's authenticity, if only because I helped translate his book on Rembrandt into English. I also doubted the authenticity until I saw the original.

If you saw the painting now, cleaned, in Dr. Naumann's gallery, you will realize that this is a stunning and authentic portrait by Rembrandt. Not only Rembrandt's name is magic, but this portrait is also.

Furthermore, you state that I purchased the Rubens for $4.25 million. In fact the hammer price was $5 million. Incidentally I did not purchase the Cornelis De Man with Dr. Naumann. And, finally, you have flopped the photographs of the Rembrandt and the De Man.

I would appreciate your publishing this letter with a colour photograph of the painting, cleaned and, this time, not flopped.

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I value Dr. Naumann's and my own reputation as connoisseurs and art dealers, and trust that you will make amends.

Sincerely yours,

AB/nik

c: Marvin Klitsner, Esq., Foley & Lardner
Dr. Otto Naumann

!!

Tümpel – not seen

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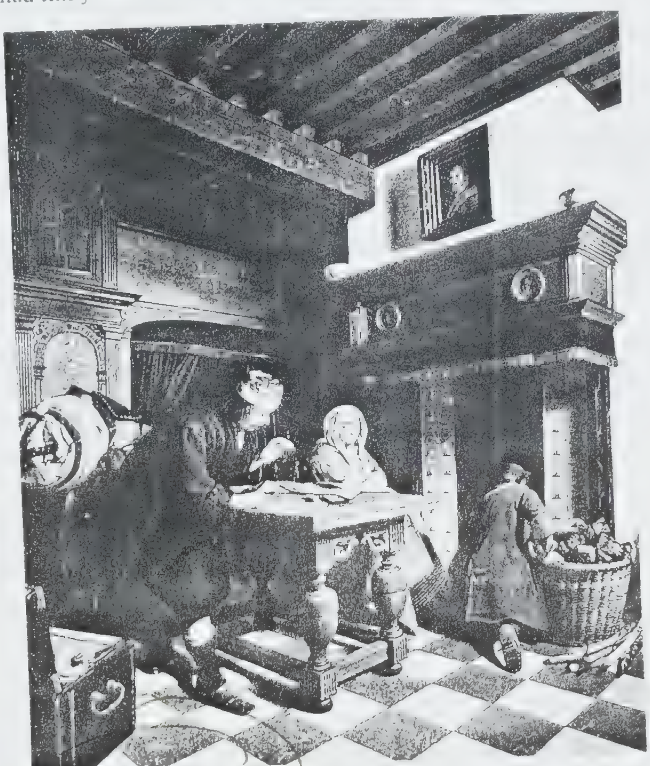
the subject with the Britons touring the area. But this one was singled out for inclusion in the Montreal Museum of Fine Arts show "Italian Recollections: Dutch Painters of the Golden Age" in 1990 and was graced more recently by Giulio Briganti's remarks in his monograph *Gaspar van Wittel*, published two years ago. A typed notice pinned next to the view stating that "the present painting has been requested for the exhibition 'The Art of Rome in the 18th century' being organized by the Philadelphia Museum of Art and the Museum of Fine Arts in Houston in 2000–2001" further added to its aura of universal admiration. That is reassuring to newcomers—not necessarily to the final bidder, but surely to some of those who ran up the view to a phenomenal $1,652,500. Needless to say, this, too, is a world record for the artist.

Such considerations are not entirely new to the market for Old Masters, but the impact they had this year is—and that, too, points to the massive entry of new players. Other subtle indications point in the same direction. Etienne Bréton, formerly a Sotheby's specialist in Old Masters and now a partner of Marc Blondeau, the Paris art broker and adviser, says he was struck by the activity displayed by John Partridge of London on January 30. Partridge is the archetypal dealer in fine 18th-century furniture, but, Breton notes, those who liked to sit upon (or to gaze at) Louis XV and Louis XVI chairs in New York used to hang Impressionists over them. The John and Frances Loeb catalogue of Impressionist and modern masters that sold at Christie's New York last May bore witness to the fact. Deterred by the rising prices and growing scarcity, those who live in an 18th-century decor now increasingly look at what goes best with it—18th-century paintings. The shift is bound to affect the strategy of Partridge, Didier Aaron and others. Did that induce Partridge to go for a pair of huge paintings better described as wall decorations done by Joseph Vernet in 1778 and pay $1.2 million, another record price? It is difficult to believe there is no connection. Similarly, a pastoral scene, credited by Sotheby's to Jean-Baptiste Marie Pierre, might have fared differently in earlier days. Purely ornamental, the work of the little-known *petit maître* would have been unlikely to make it even to its "low" estimate, set at $70,000, $79,500 including the sale premium. On January 30, Allan Salz of Didier Aaron deemed it unwise to miss the opportunity and paid, precisely, $79,500.

In this climate, famous names are a passport to roaring success, even when the substance is unimpressive. The portrait of a man with a twirling moustache and a bland expression signed "Rembrandt 1633" was the great beneficiary of changing attitudes. If the name is magic, the picture certainly is not. It is so weak that a German scholar, judging its merits from a photograph, published it as the work of a pupil. Luckily for the vendor, the Amsterdam Rembrandt Research Project Foundation approves of it and, commercially, this is all that matters. In a letter to the estate, it sets out the verdict in great detail. The panel is made from the right oak (from the Polish/Baltic area), of the right age ("the youngest heartwood ring was formed out in 1620, the earliest possible felling date is 1629," which tallies with the date) and the method of painting is the one expected from the master who would first finish the background and then elaborate the figure, etc., etc. Rembrandt is a must, and hardly any of his pictures remain in the market. That left leading dealers with no option but to go for it. Sotheby's estimate was $3 million to $4 million. Richard Green of London tried hard and gave up when bidding went well above $7 million. Alfred Bader of Milwaukee, who often buys in partnership with Otto Naumann of New York, pushed it up to $9.1 million. This reflects a policy, not a one-off grab. At the end of the sale they bought [illegible] name—Rubens. Yet, this time Bader was the only bidder. Not everyone wants to gaze at the realistic rendition of a beheaded man whose blood spurts from the neck, while his head is presented on a silver platter to a smirking woman by a sniggering old hag—not even under the title *The Head of Saint John the Baptist Presented to Salome*. It takes a highly experienced professional, who knows which institutions may decide they need a Rubens to risk $4.67 million on such a picture. But trust Bader and Naumann. They won't lose money, even if the consignor, identified as "a European financial institution," probably did—Bader's final bid, $4.25 million, was far below the $5 million unwritten estimate.



Dealers Alfred Bader of Milwaukee and Otto Naumann of New York worked in partnership to buy Cornelis de Man's *The Gold Weigher* for $552,500, one of the inspired acquisitions of the day.

Museum-targeting by dealers was a major factor that day. Throughout the sale, dealers could be observed chasing the works of artists close in spirit to now unobtainable great masters. Another Bader-Naumann purchase, *The Gold Weigher* by Cornelis de Man, is a perfect example of this search for substitutes, which could be called the "second-division gems." Sotheby's entry subtly remarks that de Man "reveals an indebtedness to Delft's other artistic progeny who specialized in intimate interior scenes, Vermeer and Pieter de Hooch." The artist is no second Vermeer, nor even another de Hooch, but he shares with both a fascination for the privileged moment when the clear cool light of Northern Europe gives an aura to every ▸

price is wrong also

AUCTION REVIEWS Old Masters

This Rembrandt portrait was the top lot at Sotheby's New York record-breaking Old Masters sale on January 30. It sold for $9,077,500 to dealers Otto Naumann and Alfred Bader.

In the wake of the third consecutive record-breaking Old Master paintings sale at Sotheby's New York on January 30, Christie's Old Masters department finds itself in much the same position as Sotheby's Imp/mod and contemporary art departments. Both led their respective fields until a few years ago, having never fully recovered from losing a handful of key staff members to the private trade. Just as Christie's triumphal Loeb and Ganz sales were partly the result of Sotheby's losing Lucy Mitchell-Innes, David Nash and Robert Monk, so Christie's Old Masters department has been gravely weakened by the departures of Simon Dickinson and Ian Kennedy in 1993. And while Christie's January 29 sale was nothing to be ashamed of, it couldn't compare in either numbers or overall quality with Sotheby's cavalcade of masterpieces and fresh commercial merchandise the following day. (Sotheby's total was $53,208,700, more than double Christie's $21,723,325.)

Christie's had its hopes set on El Greco's *A Boy Lighting a Candle* (estimate on request). Although fresh to the market, having been acquired by the Payson family in 1928 and having descended to its consignor, Virginia Kraft Payson, the work was hobbled by both its stiff $5 million-plus estimate and its unpleasantly raw appearance, caused by a harsh cleaning. Despite valiant efforts, it was bought in at $4.5 million. Two other Spanish pictures, each grime-covered recent discoveries, had a happier fate. A still life with a fruit basket on a ledge (est. $400–600,000) by Juan van der Hamen y León had been purchased last March (for around $100,000) at a small, uncatalogued sale outside Lille. Reappearing 10 months later, it was bought by London dealer restaurateur Derek Johns for $662,500. Everyone loved Zurbarán's doe-eyed *Saint Dorothea* (est. $700,000–1 million). Clad in a full-length red gown with an olive green cape, holding her emblem of a basket of flowers and fruit, she is one of the prettiest in the artist's series of doll-like, full-length female saints; the work was bought by a private American collector for $2,092,500.

Sotheby's sale on January 30 was dominated by 17th-century Flemish and Dutch pictures—the latter the strongest school in the Old Masters market, with prime examples eliciting unprecedented prices. A chic little panel (est. $10–15,000) of a turbanned Blackamoor peering out of a porthole window by the exceedingly minor Leiden *fijn schilder* Bartholomaus Maton sold to Johnny Van Haeften for $255,500, and Jan Cornelisz. Verspronck's particolored swaggering portrait of Andries Stile as a standard bearer, acquired from Otto Naumann in 1988 for $350,000 by its consignor, Canadian collector Michael Hornstien, sold to the National Gallery of Art in Washington, D.C. (via Bob Haboldt) for $1,652,500

All was overshadowed, however, by Rembrandt's *Portrait of a Bearded Man in a Red Jacket* (est. $3–4 million), consigned by the estate of Fort Worth collector (and cowboy-art aficionado) Amon Carter. Untraced since 1930 and undoubtedly authentic (having been endorsed by Ernst van der Wetering of the Stichting Foundation's Rembrandt Research Project), not to mention in excellent condition beneath its yellow varnish, it was a fine (albeit not exactly thrilling) example by a great master everyone knows. Even in its dirty state, it "screams 'Rembrandt' from across the room," in the droll words of a Sotheby's staffer. Pursued and underbid by dealers Van Haeften, Richard Green and Robert Noortman, it was won by Milwaukee dealer-collector Alfred Bader and his partner Naumann for $9,077,500. Far more exciting was a modestly sized (37 by 40 inches) yet somehow monumental panel by Sir Peter Paul Rubens of *The Head of John the Baptist Presented to Salome* with an estimate of $5 million to $7 million. Bought for approximately $100,000 at a small sale outside Versailles by Paris dealer Charles Bailly about 10 years ago, it was well known to the trade, though consigned by a "European financial institution." An early work by Rubens, painted circa 1609 in Antwerp (or possibly Italy), it was a masterpiece of blood-chilling beauty, dominated on the left by the muscular seminude executioner, who gingerly lays one foot on the headless body of his victim, and the triumphant Salome on the right. It is one of the most exciting pictures by Rubens to come on the market in recent years, but its brilliant handling and fine condition were offset in the minds of many potential buyers by the considerable panel work it needed and its "tough" subject—as a restorer noted, "Not many people want an image of a headless body spurting blood hanging over their sofa." It came very near the fate of Christie's El Greco, but was bought at the last moment by Bader and Naumann—with a single bid of $5 million ($5,502,500 with premium) against the reserve. "If we had waited 'til it was bought in," said Naumann, "there might have been a rush of post-sale offers, and we might have had to pay. This way, we *know* we have it. It's a very great picture."

Paul Jeromack

[Christie's: 245 lots offered;
$21,723,325 sold total;
30 percent unsold by dollar;
32 percent unsold by lot]
[Sotheby's: 303 lots offered;
$53,208,700 sold total;
11 percent unsold by dollar;
27 percent unsold by lot]

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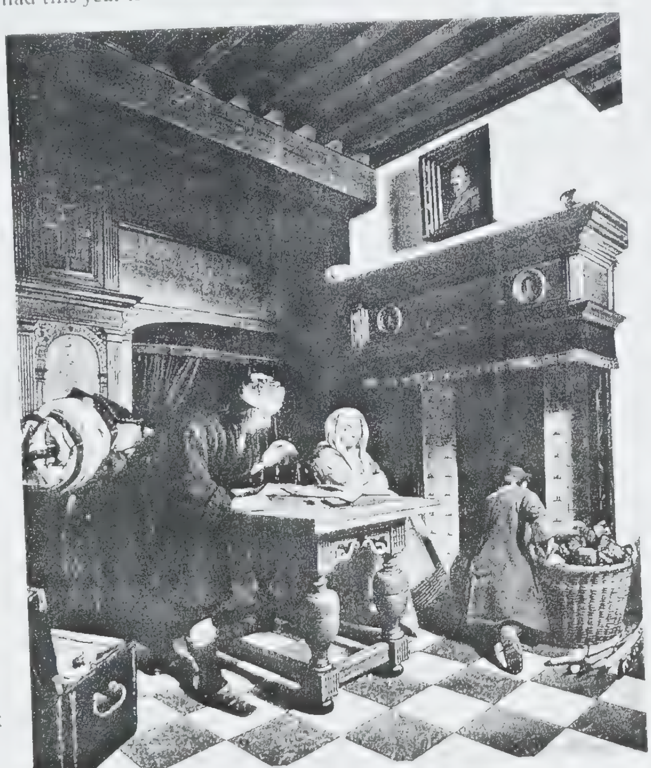
the subject with the Britons touring the area. But this one was singled out for inclusion in the Montreal Museum of Fine Arts show "Italian Recollections: Dutch Painters of the Golden Age" in 1990 and was graced more recently by Giulio Briganti's remarks in his monograph *Gaspar van Wittel*, published two years ago. A typed notice pinned next to the view stating that "the present painting has been requested for the exhibition 'The Art of Rome in the 18th century' being organized by the Philadelphia Museum of Art and the Museum of Fine Arts in Houston in 2000–2001" further added to its aura of universal admiration. That is reassuring to newcomers—not necessarily to the final bidder, but surely to some of those who ran up the view to a phenomenal $1,652,500. Needless to say, this, too, is a world record for the artist.

Such considerations are not entirely new to the market for Old Masters, but the impact they had this year is—and that, too, points to the massive entry of new players. Other subtle indications point in the same direction. Etienne Bréton, formerly a Sotheby's specialist in Old Masters and now a partner of Marc Blondeau, the Paris art broker and adviser, says he was struck by the activity displayed by John Partridge of London on January 30. Partridge is the archetypal dealer in fine 18th-century furniture, but, Breton notes, those who liked to sit upon (or to gaze at) Louis XV and Louis XVI chairs in New York used to hang Impressionists over them. The John and Frances Loeb catalogue of Impressionist and modern masters that sold at Christie's New York last May bore witness to the fact. Deterred by the rising prices and growing scarcity, those who live in an 18th-century decor now increasingly look at what goes best with it—18th-century paintings. The shift is bound to affect the strategy of Partridge, Didier Aaron and others. Did that induce Partridge to go for a pair of huge paintings better described as wall decorations done by Joseph Vernet in 1778 and pay $1.2 million, another record price? It is difficult to believe there is no connection. Similarly, a pastoral scene, credited by Sotheby's to Jean-Baptiste Marie Pierre, might have fared differently in earlier days. Purely ornamental, the work of the little-known *petit maitre* would have been unlikely to make it even to its "low" estimate, set at $70,000, $79,500 including the sale premium. On January 30, Allan Salz of Didier Aaron deemed it unwise to miss the opportunity and paid, precisely, $79,500.

In this climate, famous names are a passport to roaring success, even when the substance is unimpressive. The portrait of a man with a twirling moustache and a bland expression signed "Rembrandt 1633" was the great beneficiary of changing attitudes. If the name is magic, the picture certainly is not. It is so weak that a German scholar, judging its merits from a photograph, published it as the work of a pupil. Luckily for the vendor, the Amsterdam Rembrandt Research Project Foundation approves of it and, commercially, this is all that matters. In a letter to the estate, it sets out the verdict in great detail. The panel is made from the right oak (from the Polish/Baltic area), of the right age ("the youngest heartwood ring was formed out in 1620, the earliest possible felling date is 1629," which tallies with the date) and the method of painting is the one expected from the master who would first finish the background and then elaborate the figure, etc., etc. Rembrandt is a must, and hardly any of his pictures remain in the market. That left leading dealers with no option but to go for it. Sotheby's estimate was $3 million to $4 million. Richard Green of London tried hard and gave up when bidding went well above $7 million. Alfred Bader of Milwaukee, who often buys in partnership with Otto Naumann of New York, pushed it up to $9.1 million. This reflects a policy, not a one-off grab. At the end of the sale they bought another name—Rubens. Yet, this time Bader was the only bidder. Not everyone wants to gaze at the realistic rendition of a beheaded man whose blood spurts from the neck, while his head is presented on a silver platter to a smirking woman by a sniggering old hag—not even under the title *The Head of Saint John the Baptist Presented to Salome*. It takes a highly experienced professional, who knows which institutions may decide they need a Rubens to risk $4.67 million on such a picture. But trust Bader and Naumann. They won't lose money, even if the consignor, identified as "a European financial institution," probably did—Bader's final bid, $4.25 million, was far below the $5 million unwritten estimate.



Dealers Alfred Bader of Milwaukee and Otto Naumann of New York worked in partnership to buy Cornelis de Man's *The Gold Weigher* for $552,500, one of the inspired acquisitions of the day.

Museum-targeting by dealers was a major factor that day. Throughout the sale, dealers could be observed chasing the works of artists close in spirit to now unobtainable great masters. Another Bader-Naumann purchase, *The Gold Weigher* by Cornelis de Man, is a perfect example of this search for substitutes, which could be called the "second-division gems." Sotheby's entry subtly remarks that de Man "reveals an indebtedness to Delft's other artistic progeny who specialized in intimate interior scenes, Vermeer and Pieter de Hooch." The artist is no second Vermeer, nor even another de Hooch, but he shares with both a fascination for the privileged moment when the clear cool light of Northern Europe gives an aura to every ▸

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ALFRED BADER FINE ARTS

DR. ALFRED BADER

ESTABLISHED 1961

Re A & A

To Rachel & Otto:

Can't these characters get anything right?

R is reversed, calling it weak (!) may be actionable & I didn't buy the de Man.

Can you

(1) invite Melikian to look at the R now and publish an apology, &

(2) Have Art & Auction print with that apology a color photo of the painting unreversed.

Best wishes

Alfred

6 IV 98.

By Appointment Only
ASTOR HOTEL SUITE 622
924 EAST JUNEAU AVENUE
MILWAUKEE WISCONSIN USA 53202
TEL 414 277-0730 FAX 414 277-0709

Not

ALFRED BADER FINE ARTS

DR. ALFRED BADER

ESTABLISHED 1961

April 13, 1998

Mr. Bruce Wolmer
Editor in Chief
Art & Auction
440 Park Avenue South
14th floor
New York, NY 10016

Phone: 212 447 9555
fax 212 447 5221

Via: Certified Mail, Return Receipt Requested

Received April 16

Sir:

I have long enjoyed Souren Melikian's columns in *Art & Auction*, until I saw his comments about my purchases of a Rembrandt and a Rubens, on page 80 of your April issue. Mr. Melikian must have been tired or preoccupied when he previewed Sotheby's January 30 old master sale. Mr. Melikian's alleged that the Rembrandt "is so weak that a German scholar, judging its merit from a photograph, published it as the work of a pupil." Of course I know Professor Tümpel's doubts about the painting's authenticity, if only because I helped translate his book on Rembrandt into English. I also doubted the authenticity until I saw the original.

If you saw the painting now, cleaned, in Dr. Naumann's gallery, you will realize that this is a stunning and authentic portrait by Rembrandt. Not only Rembrandt's name is magic, but this portrait is also.

Furthermore, you state that I purchased the Rubens for $4.25 million. In fact the hammer price was $5 million. Incidentally I did not purchase the Cornelis De Man with Dr. Naumann. And, finally, you have flopped the photographs of the Rembrandt and the De Man.

I would appreciate your publishing this letter with a colour photograph of the painting, cleaned and, this time, not flopped.

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Mr. Bruce Wolmer
April 13, 1998
Page two

I value Dr. Naumann's and my own reputation as connoisseurs and art dealers, and trust that you will make amends.

Sincerely yours,

AB/nik

c: Marvin Klitsner, Esq., Foley & Lardner
Dr. Otto Naumann

To Otto:
Publication of my letter with a good photo might really help. Please consider calling Wolmer.

Thanks
Alfred
4/23

ALFRED BADER FINE ARTS

DR. ALFRED BADER

ESTABLISHED 1961

April 13, 1998

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Dr. Otto Naumann

Fce

News from CHF Affiliates

ACS Promotes Professionalism
continued

left many unemployed. The ACS responded by creating its Division of Professional Relations, thanks largely to the initiative of ACS member Thomas Fitzsimmons.

After initial opposition (some members feared such a division would run counter to the ACS's major objective—promoting the scientific and educational aspects of chemistry) and by a split vote of the Council, the Division of Professional Relations was born. Its silver anniversary marks over two decades of regular participation in ACS events and numerous symposia addressing professional concerns.

At the anniversary celebrations, held on 9 September at the ACS meeting in Las Vegas, two of the original founders, Gordon Nelson and Dennis Chamot, recounted memories of the division's beginnings. Posters honored past winners of the Henry Hill Award, presented yearly to an individual who has made outstanding contributions to chemistry professionalism. And Attila Pavlath, division chair-elect and ACS board member, officially recognized the services of former officers.

The division also presented the Lou Sacco Award for Meritorious Service to Program Chair Tom Kucera, who has organized symposia and promoted professional relations on several ACS committees. A member of the Chicago Section, Kucera has played key roles in its programming.—AB

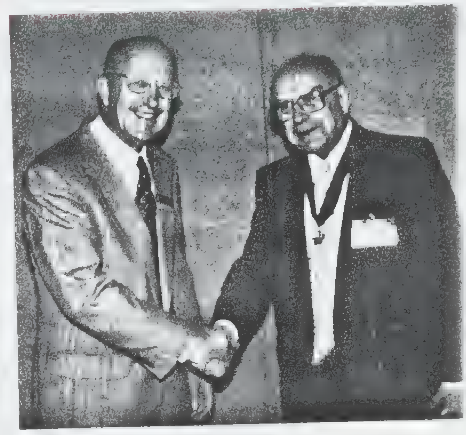
Hirl Receives Chemical Industry Medal

J. Roger Hirl, President and CEO of Occidental Chemical, received the 1997 Chemical Industry Medal from the Society of Chemical Industry, American Section, in New York City in October. He spoke about the future leaders of the chemical industry to 450 current leaders.

Hirl said that chemistry is the foundation of many modern-day miracles, among them safe drinking water and vaccines. The industry's products help make our homes, schools, and workplaces safe. These claims in themselves should be attractive enough to motivate talented youth to pursue positions in the chemical industry, yet more young people gravitate toward careers in medicine or law than enter the chemical industry.

Hirl called on his colleagues to champion education, to learn about the chemical industry's commitment to progress, and to pass its story on to students. If leaders do not become enthusiastic about their own heritage and communicate that enthusiasm to today's youth, they risk losing a pool of talented people to manage the chemical industry of the future.

Bader Receives AIC Gold Medal



Arnold Thackray, who presented the award on behalf of the AIC, congratulates Bader.

Alfred Bader, the organic chemist of almost legendary status who made a fortune with his Aldrich Chemical Company in Milwaukee, received the American Institute of Chemists' highest award, the Gold Medal, at the AIC Awards Banquet in Las Vegas on 5 September 1997. The Gold Medal Award honors an individual who has stimulated activities of service to the science of chemistry or to the profession of the chemist or chemical engineer.

Bader's nominators cited his generosity and entrepreneurial spirit. He has regularly donated Aldrich stock to universities to benefit the research programs of young academics. And as president of Aldrich he would visit clients in person to make sure Aldrich chemicals were being shipped abundantly and promptly. The Aldrich product catalog entreated clients to "please bother us."

Bader lives in England and Milwaukee and is no longer affiliated with Aldrich. He deals in art and founded the Astor Hotel art gallery in Milwaukee. His autobiography, *Adventures of a Chemist Collector*, was published in 1995.—AB

Did you know?

Combing the World

Did you know that John Wesley Hyatt discovered and developed the first commercially successful semisynthetic plastic in 1868 in Albany, New York? The new material, celluloid, moved to Leominster, Massachusetts, in 1900, after it proved suitable for making combs. Leominster was then the comb-making capital of the world; as it had been since 1774, owing to a plentiful supply of domestic cattle horns from nearby Worcester. With the expertise of the Leominster combmakers new methods, machines, and tools were developed to work the "nitrate" that soon became known as the "grandfather of all plastics." The modern legacy of this early industry is the National Plastics Center and Museum. From *APHA Notes: Newsletter of the American Plastics History Association* 1:1 (Oct. 1997) 5. (For more on this association, see page 3.)

American Chemical Society Presidents: Their Origins and Specialties

Part II, 1879–1881

T(homas) Sterry Hunt (1826–1892), the society's fourth (1879) and eleventh (1888) president, was born in Norwich, Connecticut, and studied at Yale University (1845–46), where he was assistant to Benjamin Silliman, Jr. There he published eighteen papers in Silliman's *American Journal of Science* and wrote the organic chemistry section of

Volume 15 • Number 2 Spring 1998

Chemical Heritage

Newsmagazine of the Chemical Heritage Foundation

In this issue:

Research and the Pharmaceutical

History of Cancer Chemotherapy

Chemical Reminiscences

ARTnewsletter
THE INTERNATIONAL BIWEEKLY REPORT ON THE ART MARKET
Volume XXIII, Number 12 February 10, 1998

Sotheby's $48.6 Million Record for Old Masters

NEW YORK—**Sotheby's** January 30 sale of Old Master paintings brought in a record-setting single-session total of over $48.6 million, breaking the previous single-session Old Master paintings record of £28.6 million ($48.19 million), realized at Sotheby's London last December. (The full-day total for the Sotheby's New York sale, nearly $53.2 million, also beat the $52 million total for the full day's sales in London in December.) All told, 12 paintings topped $1 million at Sotheby's—including a **Rembrandt** portrait that brought nearly $9.1 million and a **Rubens,** *The Head of John the Baptist Presented to Salome,* which went for $5.5 million—and 12 artist's records were set. Sotheby's Old Master totals were also buoyed by a January 28 sale of Old Master drawings, at which one of the last drawings by **Michelangelo** still in private hands set an auction record of close to $7.5 million. The top ten lots at **Christie's** January 29 auction of Old Master paintings did not fare so well, although records were set for six artists, among them the Spanish painter **Francisco de Zurbarán,** whose *Saint Dorothea,* from a private collection in New York, went for almost $2.1 million to an anonymous buyer. But Christie's most highly touted painting—**El Greco**'s early canvas, *A Boy Lighting a Candle* (estimated at "approximately $5 million," according to Christie's public relations office)—did not find a buyer. (**Anthony Crichton-Stuart**, head of Old Master paintings at Christie's, said afterwards that there had been "strong after-sale interest in the painting," which was consigned by **Virginia Kraft Payson** of the New York Paysons.) Altogether, Christie's sold 167 (68%) of 245 lots for a total of $21.7 million.

At the Sotheby's Old Master paintings sale, the Rembrandt and the Rubens were among the 109 (76%) lots sold in the standing-room-only morning session, at which many of the top lots were purchased by bidders in the room. The $9.07 million (estimate: $3/4 million) Rembrandt, an oval oil-on-oak panel *Portrait of a Bearded Man in a Red Coat*, went to Milwaukee-based dealer **Alfred Bader**, who also paid the sale's second-highest price, $5.5 million (just about the low estimate) for **Rubens**'s *The Head of John the Baptist Presented to Salome* (see box). (The Rembrandt and Rubens prices are the second-highest prices ever paid at auction for works by the two artists.) Bader told *ARTnewsletter* that he and his partner, New York dealer **Otto Naumann**, bought both paintings "on spec," hoping to resell them to a major museum or private collector.

"Three people were perched around $5 million for the Rubens," said Sotheby's director of Old Master paintings, **George Wachter**. "Whether they would have been if [Bader] hadn't been there, I don't know, but we certainly are very grateful to Dr. Bader." (Bader's post-sale comment on the Rubens was, "We were willing to go much higher.") Commenting on the sales in general, Wachter said, "Last January the private [collectors] came out ahead...The dealers were better armed and stronger this year."

The highest price among the dozen that set artist's records at the Sotheby's sale was the $2.09 million paid by an anonymous dealer for **Abraham Mignon**'s *Still Life* of snails, insects, and various flowers, which wildly exceeded its $200,000 high

Inside This Issue:

Bader Buys (Then Sells) Big

The big buyer of Old Masters in New York in January was a 73-year-old Austrian immigrant who made his fortune selling liquid chemicals in small lots at a time when industrial giants wouldn't handle small orders. **Alfred Bader**, in collaboration with New York dealer **Otto Naumann,** was the standout on the auction floors, spending over $14.5 million for the two top lots at **Sotheby's**. The two men have a profit-sharing arrangement, buying paintings with Bader's capital and reselling them to buyers that have included the **Rijksmuseum**, the **Art Institute of Chicago**, and the **Getty**. "The air is thin up there," Naumann said of their collaboration.

The partners were proudest of their purchase of **Rubens**'s *The Head of John the Baptist Presented to Salome*, a gruesome rendition of the New Testament scene that Bader called "an unsalable subject to any private collector." (He asked rhetorically, "Who wants a picture of a decapitated head with its tongue being pulled out?") About the **Rembrandt** portrait, Bader said, "I'm certainly convinced that it's a Rembrandt and so is the **Rembrandt Research Project**." Speaking of one painting he didn't buy, the **El Greco** offered at **Christie's,** Bader said he had been interested in bidding on it but added, "When the painting doesn't look quite as good as in the photo you hesitate. It is a fine painting, but I don't know where to go to sell it for $5 million."

UGH !

Bader retains a controlling interest in the **Sigma Aldrich Chemical Corp.**, successor to the **Aldrich Chemical Co.**, which he founded in 1951. (Sigma Aldrich's sales last year topped $1 billion.) His preferred occupation, however, is running his **Alfred Bader Fine Arts** gallery in Milwaukee. But his biggest deals are handled in collaboration with Naumann and involve players from all over the world—"People never spend more than $30,000 in Milwaukee," he said. —**Andy McCord**

estimate. A painting by **Jan Gossaert**, called **Mabuse**, *The Madonna and Child Enthroned Accompanied by Six Music-Making Angels*, sold for a record $1.65 million (estimate: $1.5/2 million). And **Jacob Isaacksz. van Ruisdael**'s *Winter Landscape* sold for a record $1.32 million, surpassing its $700/900,000 estimate.

The Michelangelo drawing sold January 28 at Sotheby's was an irregularly shaped study in black chalk of *Christ and the Woman of Samaria*. It brought just over $7.48 million, about equal to its $7.5 million high estimate (which does not include the commissions that are factored into the sale price). The previous record for a Michelangelo drawing sold at auction was the nearly $6.3 million paid for *The Rest on the Flight into Egypt*. The Michelangelo drawing sold at Sotheby's had been owned by the **Martin Bodmer Foundation** in Geneva, which is advised in its art dealings by former chairman of Sotheby's Europe **Simon de Pury** and former co-director of Sotheby's Israel **Daniella Luxembourg**, now private dealers (see *ANL*, 10/7/97). The foundation sold the 17 1/8" x 13 1/4" work—one of Michelangelo's largest drawings other than the "cartoons" done in preparation for his frescoes—to raise funds for its core rare-book collection. According to Sotheby's press office, there are only "two or three" Michelangelo drawings still in private hands.

The Sotheby's Old Master drawings sale—at which the Michelangelo far outshone its nearest competitor, a drawing by **Hans Holbein the Younger** that brought $745,000 —sold 182 (74%) of 243 lots for a total of $10.2 million. Christie's auction of Old Master drawings brought in $3.8 million, with 64 percent of 394 lots sold.

Rubens Was "Lost"

The **Rubens** painting bought by **Alfred Bader** at **Sotheby's** for $5.5 million on January 30 was the rediscovery of 1997—an important early work "lost" for over 290 years. It has been well known through copies, however. The 1609 *Head of John the Baptist Presented to Salome* turned up, according to London dealers at Sotheby's, at a French regional sale held last summer outside Paris, and was bought by a **M. de Bailly** for a "minuscule" sum understood to be close to $12,150.

Last mentioned in 1700 in the inventories of **King Philip V** of Spain at the Alcázar Palace near Madrid, the work was thought to have been destroyed when the Alcázar burned in 1734. But it mysteriously reappeared. "I'd love to own it—if I'd only bought it at the French price," sighed a London dealer. —**Godfrey Barker**

Art [illegible]
In Motion

Anonymous donor buys kids gift of better sight

By Marilynn Marchione
of the Journal Sentinel staff

When a nurse at Walker Middle School gave Megan Haas an eye exam recently, Megan confessed "I couldn't see the board or read things far away."

She revealed something else, too.

"I told my nurse that I had a sister," and that the sister used to wear glasses until hers broke last November. Their mother, a home-based day care provider for Milwaukee County, has no insurance and says she can't afford to buy a new pair.

Until a month ago, this would have been just another sad story, one more hardship case that school nurses hear but are able to do little about.

But earlier this month, both girls got glasses, thanks to an anonymous donor who gave $50,000 to start Glasses for Kids, a program that will provide eye exams and glasses for hundreds of children in Milwaukee Public Schools without insurance coverage or whose families cannot afford such care.

"This is a wonderful program," said City Health Commissioner Paul Nannis, who met with the donor last fall and put together the program, which is administered by Vision Insurance Plan of America.

City public health nurses identify children who need help and give them vouchers to get free exams and glasses at any of 29 eye care centers in the city.

Ann Riojas at Walker Middle School is one such nurse.

"I screen them for near and far vision and do a history and talk to the parents," she said. "I have a lot of kids in my school who are working poor or whose parents have no insurance."

She's referred nine children since the program began in January.

"I'm treating them like gold," Carol Chesley, a nurse at Clarke Street School, said of the 25 vouchers she's been given for her school. She identified 37 children in kindergarten through fifth grade who need glasses, and sent letters to their parents, saying the first 25 to respond would be able to get help.

Participating eye care providers, who are discounting their fees, include Stein Optical, Herslof Opticians, Vision Marts and some private optometrists.

KAREN SHERLOCK/STAFF PHOTOGRAPHER

Megan Haas, 12, admires the new glasses she got at the Vision Mart, 1818 W. National Ave., through the Glasses for Kids program. Her older sister, Ronnie, 16 (right), also got new glasses. Also looking on are Jessica Lechuga (left), an optician apprentice, and Megan's mom, Sharon.

When the program began, it was anticipated that 500 children could be helped, and the aim was kindergarten through second graders who might be having trouble reading or being successful in school because of vision problems.

It quickly became obvious that older siblings and middle school students were having problems, too.

"The target was early (ages)," Nannis said, but if health officials find an older child who needs help, "we're going to get them glasses."

Nannis hopes to seek additional donations either from the original donor and/or others to keep the program going after the initial grant runs out.

"It's evident from the demand that there are more kids" who need such help, he said.

"Next year's kids aren't going to have any less needs," Chesley agreed.

It's also possible that future initiatives could tackle other needs in children, like dental care.

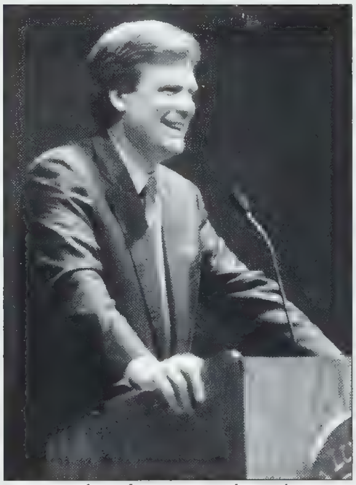
"Vision and dental are the biggest issues to deal with" after basic medical care, Chesley said

SNOW Shares View from Washington

Tony Snow spoke with students (l to r) Michelle Knuth, Nicole Moline and Matt Olejniczak.

Preceding Snow's speech, a luncheon was served to more than 100 guests.

Friday, March 6, guest speaker Tony Snow of Fox News Sunday presented "A View from Washington," his account of life in Washington D.C.



Tony Snow, host of Fox News Sunday, spoke on campus March 6.

Major topics covered in Mr. Snow's speech included President Clinton's programs and policies, the current scandals associated with Washington D.C. and the President, and the top politicians in the nation. He encouraged active participation in politics and in the mission to change the negative aspects of America's government.

Snow incorporated light humor and mild splashes of sarcasm as well. He was an animated and eloquent speaker, and did not delve into solid political content until the question-and-answer session at the end of the program. He responded to questions concerning potential presidential candidates of the future, and the professed apathetic nature of conservative and other Americans.

Overall, Tony Snow provided a unique, enjoyable first-hand perspective on current activity in the nation's capitol.

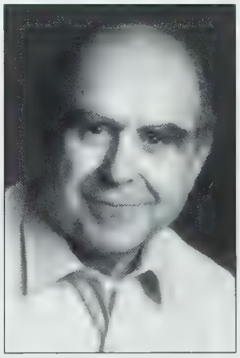
- by S. Bondow

CONVOCATION SERIES: FROM *Dealing with Grief* TO *Creating a Corporation*

Three lectures were offered as part of second semester's Convocation Series on campus, all providing a forum for learning more about subjects not always explored in the daily curriculum.

Rev. Dr. Gregory Schulz

John Chalberg



Dr. Alfred Bader

The Rev. Dr. Gregory Schulz, philosophy professor, presented "The Problem of Suffering." Schulz spoke not as a faculty member, but as the author of a book with the same title. His personal experience with the topic has affected him profoundly, and he shared much of that with his Convocation audience.

John Chalberg, a history professor and actor from Minneapolis, Minn., impersonates G.K. Chesterton, Teddy Roosevelt, and H.L. Mencken. Chalberg came to the WLC campus in March, and shared his views on the British Empire, family life, and political insights . . . all in Chestertonian garb, dialect and mannerisms.

Dr. Alfred Bader, a Milwaukee chemist, industrialist, philanthropist, author, an art collector founded the Aldrich Chemical Company. He spoke to the student body in April, and discussed his background and the creation of his company. He also shared his love for collecting fine art, and his belief in the importance of achieving a balance between appreciating the scientific, corporate arena and the cultural, artistic world.

The Convocation Series concluded with an Honors Convocation in May. The schedule for the 1998-99 Convocation Series will be announced in August.

Beyond Educational Theory

Education Professor Ray Dusseau knows there is more to being a teacher than teaching. And he wants his students to know that fact, too. That is why Dusseau encourages them to become involved in the Future Teachers Association (FTA).

"Students recognize they are receiving the theory of teaching in a classroom setting. But they need to know more. Membership in the FTA is a key way for students seeking certification as teachers to be informed about their future profession. It educates them on the workings of the larger educational community - the broader role of education. It gives them an awareness of larger issues before they even sign that first contract," says Dusseau.

One of those larger issues is the very real presence of political agendas in schools, something newly certified teachers are often ignorant of or naive about. The FTA brings such issues to the forefront, giving members routes for viewing and acting on individual political issues within the framework of their Christian faith, values and beliefs. To help in this decision-making process FTA members connect and form partnerships with public school teachers who are also Christians.

"These teachers know that sometimes the practices of the educational community will have to be measured against their Christian beliefs." Says Dusseau. "We explore how graduates can effectively take their places in those schools."

The campus chapter of the FTA is just one of 25 in Wisconsin. All chapters are part of a larger organization, the Wisconsin Education Association Council (WEAC). Officers and board members of Wisconsin Lutheran's FTA chapter represent the college at WEAC meetings held regularly in Madison. The meetings are a hands-on opportunity for officers to interact with participants from other campuses, hear about legislative news concerning education, and affect the outcome of education-related policies and programs.

Participation in WEAC has been an eye-opening experience for Mary Nelson, FTA activities director. The issues raised at the WEAC meetings and the whole legislative process have expanded Nelson's vision of what it means to be a teacher.

"There are so many complex education issues you need to know about as a teacher," says Nelson, a first semester senior. "For instance, in school I have wonderful classes on how to teach. But I don't learn anything about issues that will affect my job as a teacher, such as revenue caps, or the qualified economics offer (a contracted raise percentage for teachers). Or the fact that our governor wants bigger class sizes. I need to know these things and affect change where I need to and where I can. We do that through WEAC."

This year, as FTA activities director, Nelson organized several successful campus events relating to the field of education. One, "Read Across America" celebrated the birthday of Dr. Suess, author of such children's classics as "Green Eggs and Ham" and "The Cat in the Hat." Over 100 people joined in the fun, reading from Suess' works and participating in literacy-related activities.

Nelson also organized the FTA's Spring Conference. The conference featured three speakers who addressed areas of interest to teachers and future teachers. Bob Danner, educator and children's author and illustrator, showed the process he goes through in accomplishing his work. Wisconsin Lutheran professor Dr. Paul Boehlke discussed ways to incorporate Christian values into science curricula. Positive discipline and classroom management was the focus of a talk by Wisconsin Lutheran graduate Erin Essmann, a first-year teacher.

Dusseau thinks that Nelson is a prime example of how involvement is the key to getting the most out of FTA membership. Nelson could not agree more.

"Being in FTA has changed me as a person. I have learned how to be a better leader; how to be more flexible. I have learned how to listen better to others, be respectful. And I've learned how to be part of a team, I'm a better team player now," says Nelson.

"If it were up to me everybody in education would become a member of FTA."

Next year, when she takes on the role of Vice President of the FTA board, Nelson will do all that she can to help make that happen.

– E. Lewis

FTA activities director Mary Nelson reads from Dr. Suess classics during "Read Across America" day.

FTA CHAPTER WINS STATE AWARD

Thanks to the efforts of President Shana Retzlaff and the current association board, membership in the campus chapter of the Future Teachers Association (FTA) has grown from 35 to 46 during the 1997-1998 school year. In other words: a whopping 31 percent. In recognition of this remarkable statistic the campus chapter recently received an award for greatest percentage increase in membership from the state student Wisconsin Education Association.

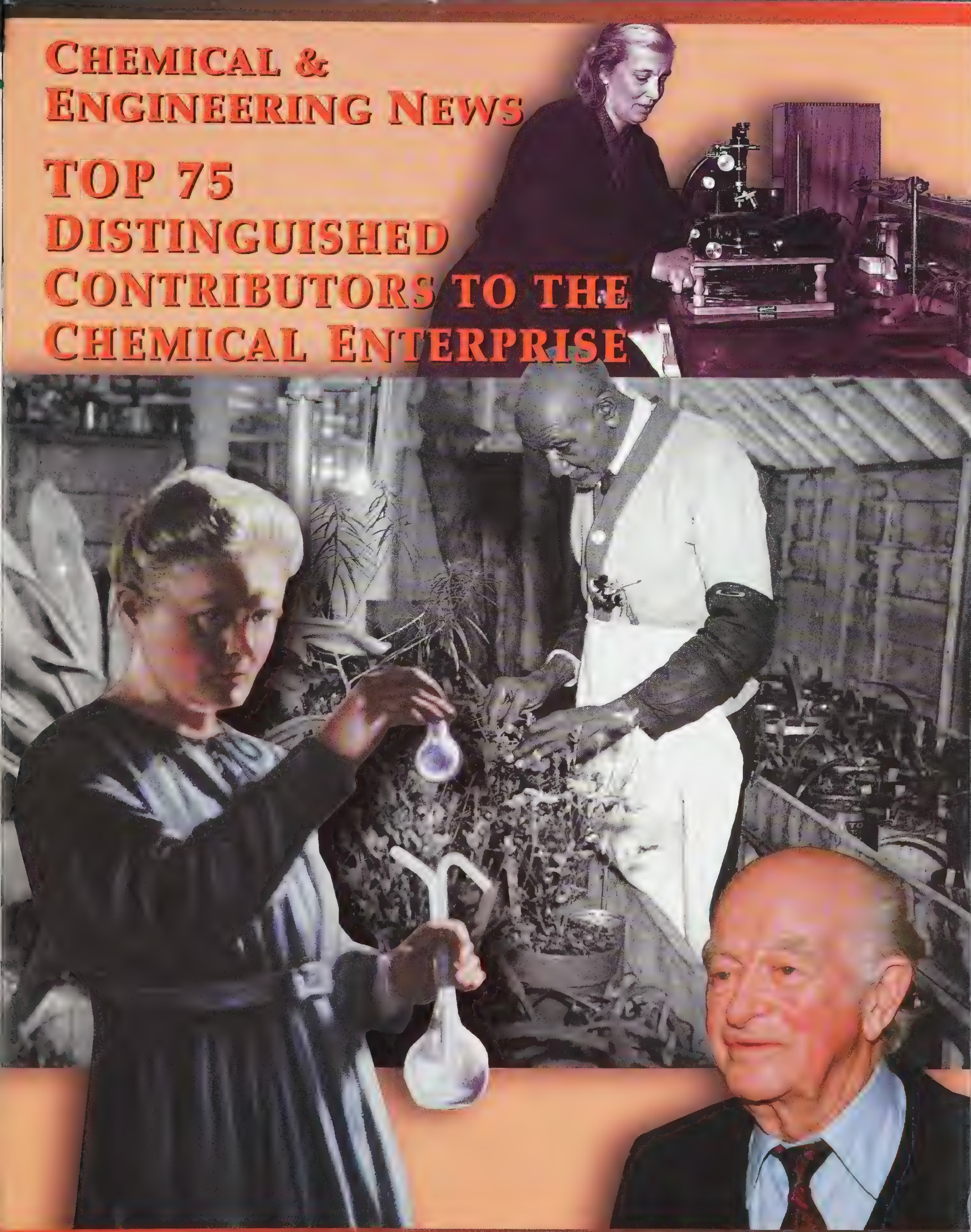
According to Retzlaff, an elementary education major and Spanish minor, the key to success was an all-out target-marketing campaign.

"We went to all the education classes and talked about the association," says Retzlaff. "We also put flyers around campus that really laid out association benefits in a way relevant to future teachers such as insurance coverage. And when we talked to interested students we really stressed those things that they could relate to. It was a real push that got results."

The campus chapter of the FTA was started in 1992 by Ray Dusseau, professor of education and chair of the social sciences department. Dusseau currently serves as faculty advisor for the group.

CHEMICAL & ENGINEERING NEWS

TOP 75 DISTINGUISHED CONTRIBUTORS TO THE CHEMICAL ENTERPRISE



C&EN's TOP 75

Chemical & Engineering News magazine, the weekly newsmagazine of the chemical world published by the American Chemical Society, marked its 75th anniversary in 1998. The magazine asked readers to nominate their choices for "C&EN's Top 75 Distinguished Contributors to the Chemical Enterprise" during the 75 years of C&EN's existence. Using a ballot in the magazine, readers could nominate up to 20 people, living or dead. Nominators were urged to think broadly and globally. Readers nominated more than 1,200 individuals. The readers' choice of C&EN Top 75 follows.

The top four vote-getters by far were Linus Pauling, Robert Woodward, Glenn Seaborg, and Wallace Carothers. After that, the votes were close. The list includes 30 living scientists and contains 35 Nobel Prize winners, 29 recipients of the American Chemical Society's prestigious Priestley Medal, and 10 winners of the ACS Arthur C. Cope Award. Collectively, the group holds 25 National Medals of Science and three National Medals of Technology. The list is a "Who's Who" of outstanding researchers, people who helped transform the nature of the chemical industry, and influential teachers.

Readers have come up with a superlative group of contributors, representing the diversity within the far-flung chemical enterprise. Chemistry is an endeavor populated by an extraordinarily large number of exceptionally talented people. Thus, it is inevitable that the list does not contain all the many well-known and brilliant contributors to the chemical enterprise, including many Nobel Prize winners, in industry, academe, and government.

C&EN's goal in its 75th anniversary year is to highlight the important contributions that chemists and chemical engineers have made to society at large. C&EN thanks its readers for helping to achieve that goal.

Madeleine Jacobs

Editor-in-Chief
Chemical & Engineering News

Top 75 Distinguished Contributors to the Chemical Enterprise

On the occasion of
C&EN's 75th Anniversary
1923–1998

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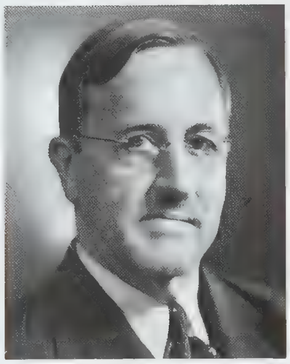
Published August 1998*

C&EN's TOP 75



Roger Adams

Jan. 2, 1889–July 6, 1971; born in Boston

Education: A.B., 1909; A.M., 1910; Ph.D., 1912; all from Harvard University

Major contributions: Developed method for preparing uniformly active palladium and platinum catalysts; structural elucidation of natural compounds; toxic alkaloids; organic synthesis; synthetic polymers; studies in steric hindrance and racemization; directed 184 doctoral theses

Major prizes: 1946 Priestley Medal; 1964 National Medal of Science; member, National Academy of Sciences

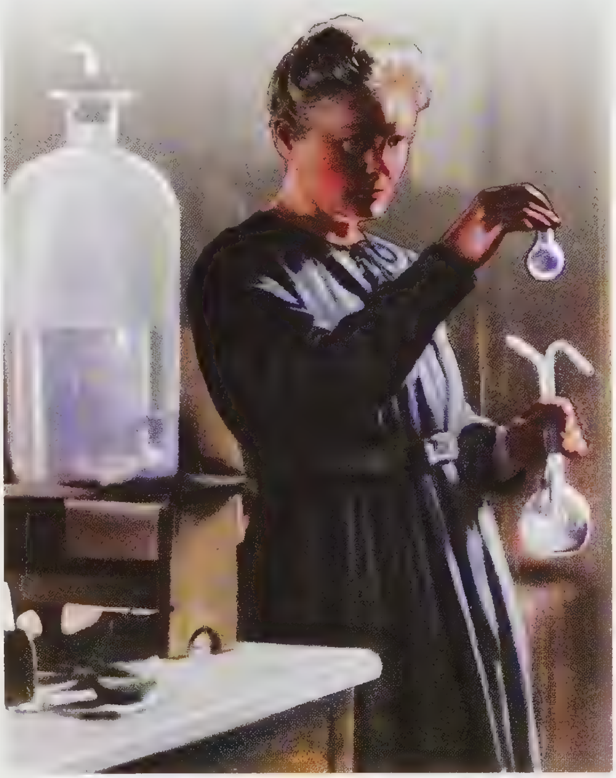
Alfred Bader

Born April 28, 1924, in Vienna, Austria

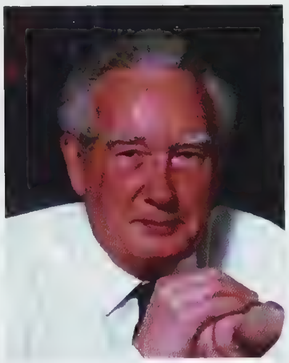
Education: B.S., 1945, Queen's University, Kingston, Ontario; B.A., 1946, Queen's University; M.S., 1947, Queen's University; M.A., 1949, Harvard University; Ph.D., chemistry, 1950, Harvard University

Major contributions: Founded Aldrich Chemical Co. in 1951; cofounded Sigma-Aldrich Corp. in 1975

Major prizes: 1995 ACS Charles Lathrop Parsons Award; 1997 Gold Medal of the American Institute of Chemists



Marie Curie



Derek Harold Richard Barton

Sept. 8, 1918–March 16, 1998; born in Gravesend, Kent, England

Education: B.S., 1940; Ph.D., organic chemistry, 1942; D.Sc., organic chemistry, 1949; all from Imperial College, London

Major contributions: Pyrolysis of chlorinated hydrocarbons; molecular rotation correlations; conformational analysis; phenolic radical coupling and biosynthesis; invention of radical reactions; selective functionalization of saturated hydrocarbons

Major prizes: 1969 Nobel Prize in Chemistry; 1959 ACS Roger Adams Medal (first awardee); 1971 Award in Natural Product Chemistry of the Chemical Society of London (first awardee); 1995 Priestley Medal; 1995 Lavoisier Medal of the French Chemical Society

Arnold Orville Beckman

Born April 10, 1900, in Cullom, Ill.

Education: B.S., 1922, University of Illinois; M.S., 1923, University of Illinois; Ph.D., photochemistry, 1928, California Institute of Technology

Major contributions: Developed pH meter; founded Beckman Instruments

Major prizes: 1988 National Medal of Technology; 1989 National Medal of Science; member, National Academy of Engineering

"Anything will give up its secrets if you love it enough. Not only have I found that when I talk to the little flower or to the little peanut they will give up their secrets, but I have found that when I silently commune with people they give up their secrets also — if you love them enough."

George Washington Carver

Ronald C. D. Breslow

Born March 14, 1931, in Rahway, N.J.

Current affiliation: Columbia University

Education: A.B., 1952; A.M., 1953; Ph.D., chemistry, 1955; all from Harvard University

Major contributions: First extended monocyclic aromaticity away from six π electron cases; proposed and demonstrated antiaromaticity; discovered chemical and biochemical reaction mechanisms; invented effective artificial enzymes; invented biomimetic functionalization methods; applied hydrophobic effect to chemical synthesis and mechanisms; invented electrochemical methods for carbon cation, radical, and anion energies; invented novel cytodifferentiation agents

Major prizes: 1987 ACS Arthur C. Cope Award; 1989 National Academy of Sciences Award in Chemical Sciences; 1990 Swiss Chemical Society Paracelsus Medal; 1991 National Medal of Science; 1999 Priestley Medal; member, National Academy of Sciences

Herbert C. Brown

Born May 22, 1912, in London

Current affiliation: Purdue University, West Lafayette, Ind.

Education: B.S., 1936; Ph.D., inorganic chemistry, 1938; both from University of Chicago

Major contributions: Diborane as facile reducing agent to aldehydes, ketones, and carboxylic acids; discovered simple synthetic routes to diborane and sodium borohydride; explored steric effects and chemical effects of steric strains; discovered hydroboration, providing ready synthesis of organoboranes; developed versatile chemistry of organoboranes; developed a general asymmetric synthesis to pure enantiomers

Major prizes: 1979 Nobel Prize in Chemistry; 1969 National Medal of Science; 1981 Priestley Medal; 1998 ACS H. C. Brown Award for Creative Work on Synthetic Methods (first awardee); member, National Academy of Sciences

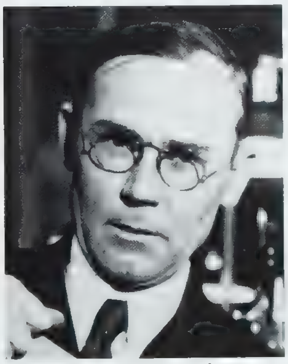
Melvin Calvin

April 8, 1911–Jan. 8, 1997; born in St. Paul, Minn.

Education: B.S., 1931, Michigan College of Mining & Technology; Ph.D., chemistry, 1935, University of Minnesota

Major contributions: Pathway of carbon in photosynthesis; organic molecular structure and behavior; coordination catalysis of metalloporphyrins

Major prizes: 1961 Nobel Prize in Chemistry; 1978 Priestley Medal; 1989 National Medal of Science; member, National Academy of Sciences



Wallace Hume Carothers

April 27, 1896–April 29, 1937; born in Burlington, Iowa

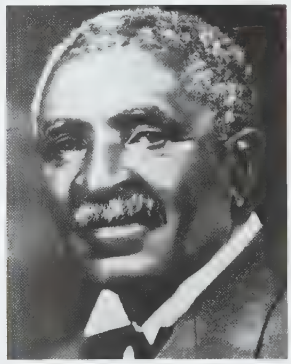
Education: B.S., 1920, Tarkio College, Missouri; M.S., 1921, University of Illinois; Ph.D., chemistry, 1924, University of Illinois

Major contributions: Development of neoprene and nylon at DuPont

C&EN's TOP 75

"I can't think of anything in the world that I would want that I haven't had.... I have my marriage, two wonderful children. I have a laboratory that is an absolute joy. I have energy. I have health. As long as there is anything to be done, I am never tired."

Rosalyn Sussman Yalow



George Washington Carver

Early 1860s–Jan. 5, 1943; born in Diamond Grove, Mo.

Education: B.S., 1894; M.S., 1896; both from Iowa Agricultural College

Major contributions: Developed industrial applications for farm products such as peanuts, sweet potatoes, and pecans; derived a rubber substitute and more than 500 dyes and pigments from 28 different plants; paints and stains from soybeans

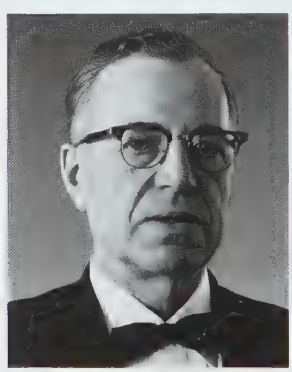
James Bryant Conant

March 26, 1893–Feb. 11, 1978; born in Dorchester, Mass.

Education: B.S., 1913; Ph.D., 1916; both from Harvard University

Major contributions: Pioneer in physical chemistry; acid-base catalysis; existence of superacids; director of National Defense Research Committee during World War II; established coeducation at Harvard University; author of books on public education

Major prizes: 1944 Priestley Medal



Arthur Clay Cope

June 27, 1909–June 4, 1966; born in Dunreith, Ind.

Education: Bachelor's degree, 1929, Butler University, Indianapolis; Ph.D., 1932, University of Wisconsin

Major contributions: Chemistry of medium-sized ring compounds; transannular reactions; rearrangement of allyl groups in three-carbon systems; work in synthetic organic chemistry

Major prizes: 1965 ACS Roger Adams Award in Organic Chemistry

Elias James Corey

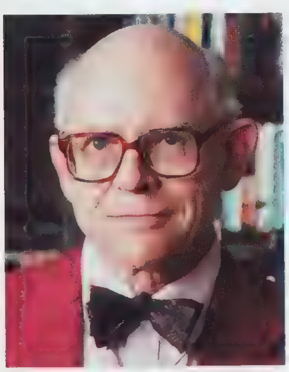
Born July 12, 1928, in Methuen, Mass.

Current affiliation: Harvard University

Education: B.S., 1948; Ph.D., chemistry, 1951; both from Massachusetts Institute of Technology

Major contributions: Development of the fundamental logic of chemical synthesis and many generally useful reactions and methods for synthesis; achievement of total synthesis of more than 100 complex, biologically active molecules; use of computers in chemistry; theory and stereochemistry of organic reactions; stereoelectronic effects in organic reactions; importance of orbital symmetry in control cycloaddition and pericyclic reactions; enantioselective catalysis

Major prizes: 1990 Nobel Prize in Chemistry; 1976 ACS Arthur C. Cope Award; 1986 Wolf Prize; 1988 National Medal of Science; member, National Academy of Sciences



F. Albert Cotton

Born April 9, 1930, in Philadelphia

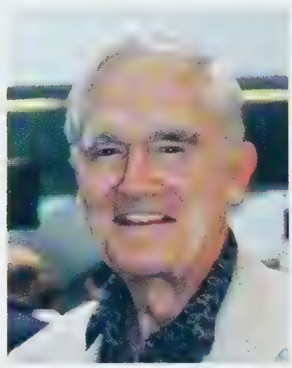
Current affiliation: Texas A&M University, College Station

Education: A.B., 1951, Temple University; Ph.D., chemistry, 1955, Harvard University

George Washington Carver

Major contributions: Work in inorganic chemistry, protein chemistry, structural chemistry, and chemical bonding; originator of the field of compounds containing single and multiple bonds between metal atoms; contributed in the fields of protein structure, spectroscopic studies of metal carbonyls, and dynamic behavior of fluxional organometallic and metal carbonyl compounds

Major prizes: 1982 National Medal of Science; 1990 National Academy of Sciences Award in Chemical Sciences; 1994 Welch Award in Chemistry; 1998 Priestley Medal; member, National Academy of Sciences



Donald J. Cram

Born April 22, 1919, in Chester, Vt.

Current affiliation: University of California, Los Angeles

Education: B.S., 1941, Rollins College, Winter Park, Fla.; M.S., 1942, University of Nebraska; Ph.D., organic chemistry, 1947, Harvard University

Major contributions: Application of stereochemical techniques to organic reaction mechanisms (for example, phenonium ions, Cram's rule, asymmetric solvation of carbanions); introduced cyclophane transannular effect studies; introduced host-guest synthetic organic chemical binding systems as models for biological processes; studied structural and chiral recognition in binding; invented carceplexes (guest molecules completely encapsulated by hosts)

Major prizes: 1987 Nobel Prize in Chemistry; 1974 ACS Arthur C. Cope Award; 1992 National Academy of Sciences Award in Chemical Sciences; 1993 National Medal of Science; member, National Academy of Sciences

Francis Harry Compton Crick

Born June 8, 1916, in Northampton, England

Current affiliation: Salk Institute of Biological Studies, San Diego

Education: B.S., 1937, University College, London; Ph.D., 1954, Cambridge University

Major contributions: Determined structure of DNA; studies of mammalian brain

Major prizes: 1962 Nobel Prize in Physiology or Medicine; foreign associate, National Academy of Sciences

Marie Curie

Nov. 7, 1867–July 4, 1934; born in Warsaw, Poland

Education: Master's degree, 1894, Sorbonne; doctoral degree, 1903, University of Paris

Major contributions: Defined radioactivity; discovery of radium and polonium

Major prizes: 1903 Nobel Prize in Physics; 1911 Nobel Prize in Chemistry

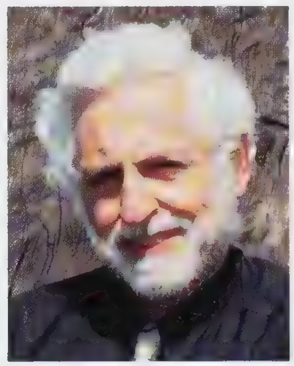
Peter Joseph William Debye

March 24, 1884–Nov. 2, 1966; born in Maastricht, the Netherlands

Education: Bachelor's degree, 1905, Technische Hochschule, Aachen; Ph.D., physics, 1908, Ludwig-Maximilian University

Major contributions: Determination and definition of dipole moment; powder method of X-ray diffraction

Major prizes: 1936 Nobel Prize in Chemistry; 1963 Priestley Medal



Carl Djerassi

Born Oct. 29, 1923, in Vienna, Austria

Current affiliation: Stanford University

Education: A.B., 1942, Kenyon College, Gambier, Ohio; Ph.D., organic chemistry, 1945, University of Wisconsin, Madison

Major contributions: Structure elucidation of natural products (antibiotics, alkaloids, steroids, and terpenoids); synthesis of medicinals (antihistamines, anti-inflammatory agents, oral contraceptives, hormone analogs); applications of physical measurements (notably optical rotatory dispersion, magnetic circular dichroism, and mass spectrometry) and computer artificial intelligence techniques to organic chemical problems

Major prizes: 1973 National Medal of Science; 1973 ACS Award for Creative Invention; 1978 Wolf Prize in Chemistry; 1991 National Medal of Technology; 1992 Priestley Medal; member, National Academy of Sciences

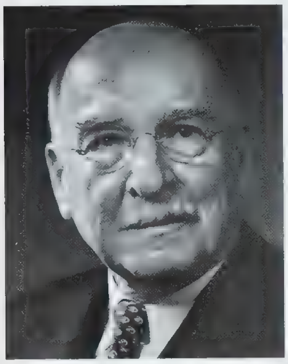
Herbert Henry Dow

Feb. 26, 1866–Oct. 15, 1930; born in Belleville, Ontario

Education: Bachelor's degree, 1888, Case Institute of Applied Science

Major contributions: Formed Dow Chemical

Co. in 1897; reinvented manufacturing process for bromine and other industrial chemicals; helped to break stranglehold of powerful European cartels

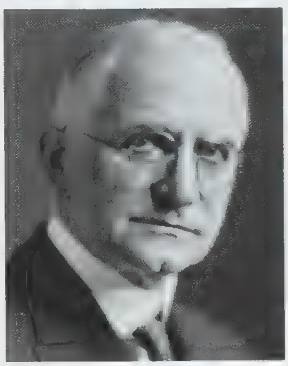


Pierre Samuel DuPont

Jan. 15, 1870–April 5, 1954; born in Wilmington, Del.

Education: Bachelor's degree,1890, Massachusetts Institute of Technology

Major contributions: Worked at DuPont 1902–20; president of DuPont 1915–20; transformed the premier U.S. explosives maker, E. I. du Pont de Nemours, into the well-known diversified chemical producer



George Eastman

July 2, 1854–March 14, 1932; born in Waterville, N.Y.

Major contributions: Process for making dry plates for photography and a machine to make large numbers of dry plates; established Eastman Dry Plate & Film Co. in 1884, which became Eastman Kodak in 1892; developed transparent film and Brownie camera with removable film

"Behold the turtle. He makes progress only when he sticks his neck out."

James Bryant Conant

Wallace Hume Carothers

Ernest L. Eliel

Born Dec. 28, 1921, in Cologne, Germany

Current affiliation: University of North Carolina, Chapel Hill

Education: B.S., 1946, University of Havana; Ph.D., chemistry, 1948, University of Illinois, Urbana-Champaign

Major contributions: Organic stereochemistry and conformational analysis, including three landmark books: "Stereochemistry of Carbon Compounds" (1962), "Conformational Analysis" (1965, coauthored), "Stereochemistry of Organic Compounds" (1994, with S. H. Wilen); coeditor of Topics in Stereochemistry (1965–94)

Major prizes: 1968 Lavoisier Medal of the French Chemical Society; 1995 ACS George C. Pimentel Award in Chemical Education; 1996 Priestley Medal; 1997 National Academy of Sciences Award for Chemistry in Service to Society; member, National Academy of Sciences

Gertrude B. Elion

Born Jan. 23, 1918, in New York City

Current affiliation: Glaxo Wellcome

Education: B.A., 1937, Hunter College; M.S., chemistry, 1941, New York University

Major contributions: Rational design, synthesis, and development of therapeutic agents: 6-mercaptopurine and 6-thioguanine for the treatment of acute leukemia and azathioprine for the prevention of kidney transplant rejection; played a major role in the development of allopurinol for the treatment of gout; acyclovir, a selective antiviral agent for herpes virus infections

Major prizes: 1988 Nobel Prize in Physiology or Medicine; 1968 ACS Francis P. Garvan Medal; 1991 National Medal of Science; 1997 Lemelson/Massachusetts Institute of Technology Lifetime Achievement Award; member, National Academy of Sciences

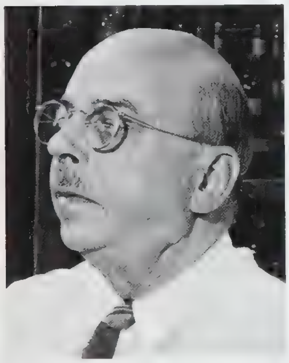
Henry Eyring

Feb. 20, 1901–Dec. 26, 1981; born in Colonia Juarez, Mexico

Education: B.S., 1923, University of Arizona; M.S., 1924, University of Arizona; Ph.D., chemistry, 1927, University of California, Berkeley

Major contributions: Transition-state theory; chemical kinetics; construction of first potential energy surface for a reaction

Major prizes: 1975 Priestley Medal; member, National Academy of Sciences



Louis Frederick Fieser

April 7, 1899–July 25, 1977; born in Columbus, Ohio

Education: B.A., 1920, Williams College; Ph.D., 1924, Harvard University

Major contributions: Chemistry of aromatic compounds, especially quinones and hydroquinones; new synthetic route to anthraquinones; synthesis of vitamin K; identification of carcinogens; "Steroids" reference work; coauthor of 17-volume series "Reagents for Organic Synthesis"

Major prizes: Member, National Academy of Sciences

"Clearly, some people are smarter than others or much stronger than others. Yet, there is some GOD in each of us."

Alfred Bader

Mary Fieser

May 27, 1909–March 22, 1997; born in Atchison, Kan.

Education: Bachelor's degree, 1930, Bryn Mawr College; M.S., organic chemistry, Radcliffe College

Major contributions: Research on quinones, natural products, steroids; coauthored "Basic Organic Chemistry", "Advanced Organic Chemistry", "Style Guide for Chemists", "Steroids", and 17-volume series "Reagents for Organic Synthesis"

Paul John Flory

July 19, 1910–Sept. 8, 1985; born in Sterling, Ill.

Education: B.S., 1931, Manchester College; Ph.D., 1934, Ohio State University

Major contributions: Physical chemistry of macromolecules; solved excluded-volume problem of polymers in solution; spatial configuration of chain molecules; thermodynamics of solutions; authored "Principles of Polymer Chemistry"

Major prizes: 1974 Nobel Prize in Chemistry; 1974 Priestley Medal

Mary Lowe Good

Born June 20, 1931, in Grapevine, Texas

Current affiliation: Venture Capital Investors Inc.

Education: B.S., 1950, University of Central Arkansas; M.S., 1953, University of Arkansas; Ph.D., chemistry, 1955, University of Arkansas

Major contributions: Served in research and leadership positions at Louisiana State University and at AlliedSignal; provided science and technology advice and leadership as undersecretary for technology of the Department of Commerce, member of the National Science Board, and chairman of the President's Council of Advisers on Science & Technology; leadership in ACS as a board member and as 1987 ACS president

Major prizes: 1992 National Science Foundation Distinguished Public Service Award; 1995 honorary fellowship, Royal Society of Chemistry; 1996 ACS Earle B. Barnes Award for Leadership in Chemical Research Management; 1997 Priestley Medal; 1998 Othmer Gold Medal of the Chemical Heritage Foundation; member, National Academy of Engineering

Harry B. Gray

Born Nov. 14, 1935, in Woodburn, Ky.

Current affiliation: California Institute of Technology

Education: B.S., 1957, Western Kentucky University; Ph.D., chemistry, 1960, Northwestern University

Major contributions: Landmark work on the electronic structures of inorganic compounds and metalloproteins; on inorganic spectroscopy and photochemistry, particularly for complexes containing metal-metal bonds; and on the mechanisms of inorganic and bioinorganic reactions; cofounder of the field of bioinorganic chemistry; pioneered the study of electron transfer in proteins

Major prizes: 1986 National Medal of Science; 1986 Linus Pauling Medal; 1988 California Scientist of the Year; 1991 Priestley Medal; member, National Academy of Sciences

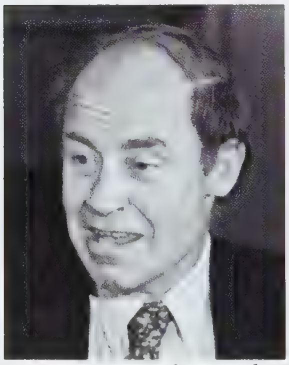
Louis Plack Hammett

April 7, 1894–Feb. 23, 1987; born in Wilmington, Del.

Education: A.B., 1916, Harvard University; Ph.D., 1923, Columbia University

Major contributions: Quantitative structure-activity relationships (QSAR); correlation of electronic properties of acids and bases with equilibrium constants and reactivity; developed Hammett equation for linear free-energy relationships and the correlation of changes in chemical properties with chemical structure

Major prizes: 1961 Priestley Medal; 1967 National Medal of Science; member, National Academy of Sciences



Dudley Robert Herschbach

Born June 18, 1932, in San Jose, Calif.

Current affiliation: Harvard University

Education: B.S., 1954, Stanford University; M.S., 1955, Stanford University; A.M., 1956, Harvard University; Ph.D., chemical physics, 1958, Harvard University

Major contributions: Development of molecular beam methods for study of elementary chemical reaction dynamics

Major prizes: 1986 Nobel Prize in Chemistry; 1991 National Medal of Science; member, National Academy of Sciences

Joel Henry Hildebrand

Nov. 16, 1881–April 30, 1983; born in Camden, N.J.

Education: B.S., 1903; Ph.D., 1906; both from the University of Pennsylvania

Major contributions: Behavior of liquids and nonelectrolyte solutions; authored "Principles of Chemistry" textbook; science education

Major prizes: 1952 ACS Award in Chemical Education; 1962 Priestley Medal; member, National Academy of Sciences

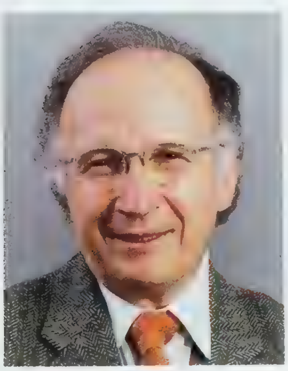
Dorothy Mary Crowfoot Hodgkin

May 12, 1910–July 30, 1994; born in Cairo, Egypt

Education: Bachelor's degree, 1932, Somerville College, Oxford, England; Ph.D., 1937, Cambridge University

Major contributions: Use of X-ray diffraction techniques to determine the structure of complex compounds including vitamin B-12, penicillin, and insulin

Major prizes: 1964 Nobel Prize in Chemistry



Roald Hoffmann

Born July 18, 1937, in Zloczow, Poland

Current affiliation: Cornell University

Education: B.A., 1958, Columbia College; M.A., 1960, Harvard University; Ph.D., chemical physics, 1962, Harvard University

"Nothing in life is to be feared, it is only to be understood."

Marie Curie

Major contributions: Established qualitative molecular-orbital-based ways of thinking about the electronic and geometrical structure and reactivity of all molecules—organic, inorganic, organometallic, surface, and extended structures; rules for predicting course of pericyclic reactions

Major prizes: 1981 Nobel Prize in Chemistry; 1973 ACS Arthur C. Cope Award; 1983 National Medal of Science; 1986 National Academy of Sciences Award in the Chemical Sciences; 1990 Priestley Medal; member, National Academy of Sciences

Rosalyn Sussman Yalow

Christopher Kelk Ingold

Oct. 28, 1893–Dec. 8, 1970; born in London

Education: B.S., 1913, University of Southampton, England; M.S., 1913, Imperial College, London; D.Sc., 1919, Imperial College, London

Major contributions: Electronic theory of organic reaction mechanisms; structure and mechanism in organic chemistry; terminology of physical organic chemistry; sequence rules for defining absolute configuration

Major prizes: Fellow, Royal Society of Chemistry

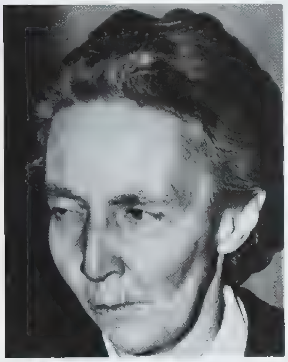
William Summer Johnson

Feb. 24, 1913–Aug. 19, 1995; born in New Rochelle, N.Y.

Education: A.B., 1936, Amherst College; A.M., 1938, Harvard University; Ph.D., 1940, Harvard University

Major contributions: New and more efficient ways to synthesize complex molecules, including corticoid steroids

Major prizes: 1987 National Medal of Science; 1989 ACS Arthur C. Cope Award; member, National Academy of Sciences



Irène Joliot-Curie

Sept. 12, 1897–March 17, 1956; born in Paris

Education: Bachelor's degree, 1914, Collège Sévigné; doctorate, 1920, Sorbonne

Major contributions: Discovery of artificial radioactivity; her work led to the discovery of the neutron and fission

Major prizes: 1935 Nobel Prize in Chemistry

Percy Lavon Julian

April 11, 1899–April 19, 1975; born in Montgomery, Ala.

Education: B.S., 1920, DePauw University; M.S., 1923, Harvard University; Ph.D., 1931, University of Vienna

Major contributions: Synthesis of physostigmine and cortisone

Major prizes: Member, National Academy of Sciences

Ralph Landau

Born May 19, 1916, in Philadelphia

Current affiliation: Listowel Inc.

Education: B.S., 1937, University of Pennsylvania; Sc.D., chemical engineering, 1941, Massachusetts Institute of Technology

Major contributions: Cofounded Scientific Design in 1946; led company in development of the current terephthalic acid process used in most polyester manufacture; the propylene oxide process used in many urethane products; and cyclohexane oxidation, which is used in many nylon precursor operations

Major prizes: 1973 Chemical Industry Medal; 1981 Perkin Medal; 1985 National Medal of Technology; 1997 Othmer Gold Medal of the Chemical Heritage Foundation; member, National Academy of Engineering

Irving Langmuir

Jan. 31, 1881–Aug. 16, 1957; born in Brooklyn

Education: Bachelor's degree, 1903, Columbia University School of Mines; Ph.D., 1906, University of Göttingen

Major contributions: Invention of high-vacuum electron tube and gas-filled incandescent lamp; development of modern surface chemistry; theory of adsorption catalysis; discovery of monomolecular films; molecular orientation at surfaces; understanding of plasmas, heat transfer, and thermionic phenomena

Major prizes: 1932 Nobel Prize in Chemistry; fellow, Royal Society of Chemistry; member, National Academy of Sciences

Jean-Marie Lehn

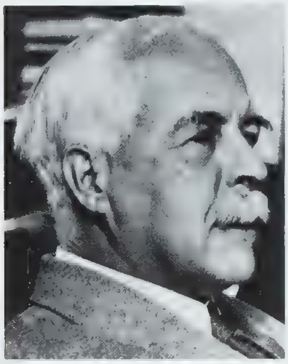
Born Sept. 30, 1939, in Rosheim, Alsace, France

Current affiliation: Collège de France

Education: B.S., 1960; Ph.D., 1963; both from the University of Strasbourg

Major contributions: Supramolecular chemistry: cryptates, molecular recognition, molecular receptors and coreceptors, supramolecular catalysis; transport processes; self-assembly and self-organization; supramolecular materials; chemionics: molecular photonic, electronic, and ionic devices; semiochemistry; two books, including "Supramolecular Chemistry: Concepts and Perspectives" (1997)

Major prizes: 1987 Nobel Prize in Chemistry; 1982 Swiss Chemical Society Paracelsus Medal; 1997 Lavoisier Medal of the French Chemical Society; 1997 Davy Medal of the Royal Society; foreign associate, National Academy of Sciences



Gilbert Newton Lewis

Oct. 23, 1875–March 23, 1946; born in Weymouth, Mass.

Education: A.B., 1896; M.A., 1898; Ph.D., 1899; all from Harvard University

Major contributions: Theory of chemical bonding and valence, based on concept of shared electron pair; acids and bases as electron pair acceptors and donors

Rudolph Arthur Marcus

Born July 21, 1923, in Montreal, Quebec

Current affiliation: California Institute of Technology

Education: B.Sc., 1943; Ph.D., chemistry, 1946; both from McGill University

Major contributions: Marcus theory of electron-transfer reactions in chemical, electrochemical, and biological systems; RRKM (Rice-Ramsperger-Kassel-Marcus) theory of unimolec-

"What greater joy can you have than to know what an impact your work has had on peoples' lives? We get letters from people all the time, from children who are living with leukemia. And you can't beat the feeling that you get from those children."

Gertrude B. Elion

ular reactions and bimolecular association reactions; semiclassical and intramolecular dynamics of reactions

Major prizes: 1992 Nobel Prize in Chemistry; 1985 Wolf Prize in Chemistry; 1989 National Medal of Science; foreign member, Royal Society of London; member, American Philosophical Society

George Eastman (left) and Thomas Edison

Herman F. Mark

May 3, 1895–April 6, 1992; born in Vienna, Austria

Education: Ph.D., 1921, University of Vienna

Major contributions: Development of polymer science; structural determination of natural polymers; development of new polymers, including polyvinyls and polyacrylics

Major prizes: Member, National Academy of Sciences

Carl (Speed) Marvel

Sept. 11, 1894–Jan. 4, 1988; born in Waynesville, Ill.

Education: B.S., 1915, Illinois Wesleyan University; M.S., 1915, Illinois Wesleyan University; Ph.D., 1920, University of Illinois

Major contributions: Development of polymer science; vinyl polymers; high-temperature-resistant polymers

Major prizes: 1956 Priestley Medal; member, National Academy of Sciences

Samuel Proctor Massie Jr.

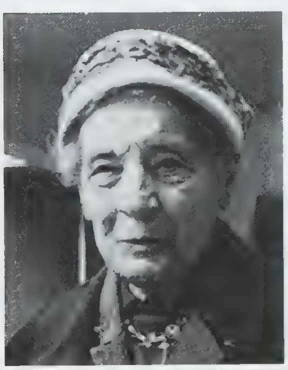
Born July 3, 1919, in North Little Rock, Ark.

Current affiliation: U.S. Naval Academy, Annapolis, Md.

Education: B.S., 1938, A.M.N. College, Arkansas; M.A., 1940, Fisk University; Ph.D., organic chemistry, 1946, Iowa State University

Major contributions: Studies in silicon chemistry; chemistry of phenothiazine; antimalarial-antibacterial agents; studies on environmental agents; encouraging disadvantaged students into science careers; Samuel P. Massie Chair of Excellence Program established in 1994 by the Department of Energy committing $14.7 million in grants over a five-year period to nine historically black colleges and universities and one Hispanic-serving institution

Major prizes: 1980 NOBCChE Teaching Award; 1994 ACS James Flack Norris Award for Outstanding Achievement in Teaching Chemistry; 1996 ACS Award for Encouraging Disadvantaged Students into Careers in the Chemical Sciences



Lise Meitner

Nov. 7, 1878–Oct. 27, 1968; born in Vienna, Austria

Education: Ph.D., 1905, University of Vienna

Major contributions: Discovery of protactinium; chemistry of radioactivity; codiscoverer of nuclear fission

"The best way to have a good idea is to have a lot of ideas."

Linus Pauling

R. Bruce Merrifield

Born July 15, 1921, in Fort Worth, Texas

Current affiliation: Rockefeller University

Education: B.A., 1943; Ph.D., biochemistry, 1949; both from University of California, Los Angeles

Major contributions: Conceived and developed solid-phase peptide synthesis and applied it to the chemical synthesis of various growth factors, antibiotics, hormones, and effective antagonists of glucagon; completed the first total synthesis of an enzyme; technique now used for the combinatorial synthesis of peptide and nonpeptide libraries

Major prizes: 1984 Nobel Prize in Chemistry; 1972 ACS Award for Creative Work in Synthetic Organic Chemistry; 1987 Royal Society of Chemistry Medal; 1993 Glenn T. Seaborg Medal; member, National Academy of Sciences

Robert Sanderson Mulliken

June 7, 1896–Oct. 31, 1986; born in Newburyport, Mass.

Education: B.S., 1917, Massachusetts Institute of Technology; Ph.D., 1921, University of Chicago

Major contributions: Codeveloper of molecular orbital theory; electronic structure of molecules

Major prizes: 1966 Nobel Prize in Chemistry; 1983 Priestley Medal; member, National Academy of Sciences

Giulio Natta

Feb. 26, 1903–May 2, 1979; born in Imperia, Liguria, Italy

Education: Dottore degree, 1924; Libero Docente degree, 1927; both from Milan Polytechnic Institute

Major contributions: Discovery and elucidation of stereospecific polymerization and stereoregular polymers; development of commercially important polymerization processes

Major prizes: 1963 Nobel Prize in Chemistry

George A. Olah

Born May 22, 1927, in Budapest, Hungary

Current affiliation: University of Southern California

Education: Ph.D., chemistry, 1949, Technical University of Budapest

Major contributions: Study of carbocations as long-lived species in superacids and investigation of related hydrocarbon chemistry, including development of environmentally benign and safe processes; study of new synthetic reagents and methods; structural and mechanistic studies in organic chemistry

Major prizes: 1994 Nobel Prize in Chemistry; 1964 ACS Award in Petroleum Chemistry; 1979 ACS Award for Creative Work in Synthetic Organic Chemistry; 1989 ACS Roger Adams Award in Organic Chemistry; member, National Academy of Sciences

C&EN's TOP 75

“The award to the educator lies in his pride in his students' accomplishments. The richness of that reward is the satisfaction in knowing that the frontier of knowledge has been extended.”

Donald Frederick Othmer

Donald Frederick Othmer

May 11, 1904–Nov. 1, 1995; born in Omaha, Neb.

Education: B.ChE., 1924, University of Nebraska; M.ChE., 1925, University of Michigan, Ann Arbor; Ph.D., chemical engineering, 1927, University of Michigan, Ann Arbor

Major contributions: Cofounder and editor of *Kirk-Othmer Encyclopedia of Chemical Technology;* development of Polytechnic University of Brooklyn's chemical engineering program; solutions to problems in manufacturing plastics, food, textiles, and pharmaceuticals

Charles Lathrop Parsons

March 23, 1867–Feb. 13, 1954; born in New Marlboro, Mass.

Education: B.S., 1888, Cornell University; D.Sc., 1911, University of Maine

Major contributions: Chemistry of beryllium; organized project to develop an American process for extracting radium from Colorado and Utah carnotite, which led to establishment of National Radium Institute; authority on nitrogen fixation, uranium, and radium; obtained federal charter for ACS; directed gift of ownership of Universal Oil Products Co. into a trusteeship under which ACS administers the Petroleum Research Fund grants

Major prizes: 1932 Priestley Medal

Linus Carl Pauling

Feb. 28, 1901–Aug. 19, 1994; born in Portland, Ore.

Education: Bachelor's degree, 1922, Oregon Agricultural College; Ph.D., 1925, California Institute of Technology

Major contributions: Nature of the chemical bond; valence bond theory; concepts of electronegativity, resonance, and hybridization; application of structural chemistry to biological molecules

Major prizes: 1954 Nobel Prize in Chemistry; 1962 Nobel Peace Prize; 1948 Presidential Medal of Merit for outstanding service during World War II; 1984 Priestley Medal; member, National Academy of Sciences

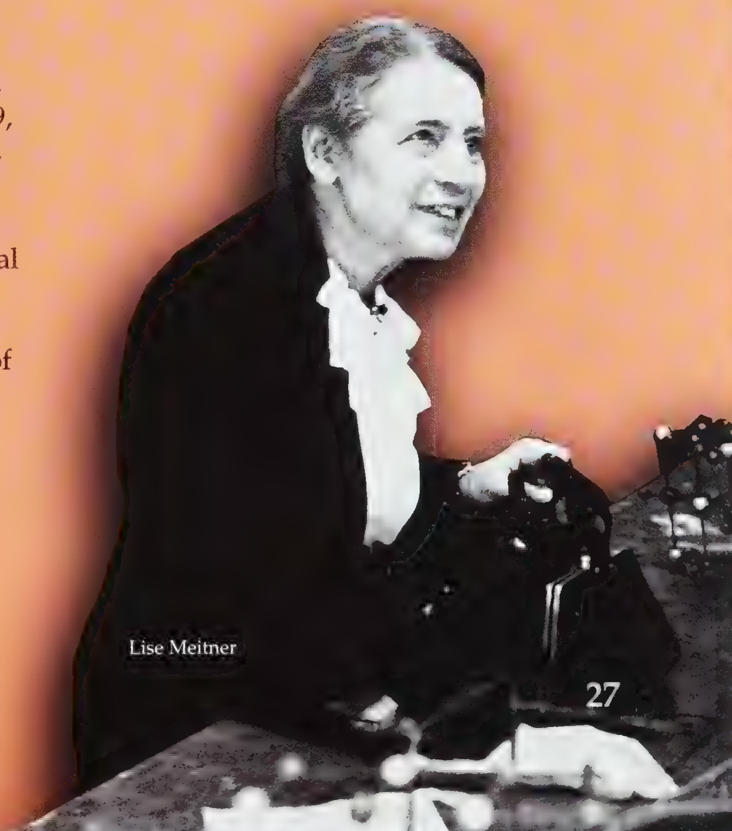
George Claude Pimentel

May 2, 1922–June 1, 1989; born in Rolinda, Calif.

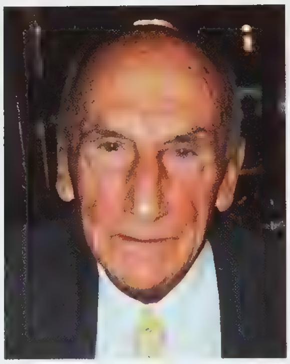
Education: A.B., 1943, University of California, Los Angeles; Ph.D., 1949, University of California, Berkeley

Major contributions: Development of chemical lasers, matrix isolation techniques, and rapid-scan IR spectroscopy; designed instruments for interplanetary spacecraft; revitalized teaching of chemistry in high schools

Major prizes: 1983 National Medal of Science; 1989 Priestley Medal; member, National Academy of Sciences



Lise Meitner



Vladimir Prelog

July 23, 1906–Jan. 7, 1998; born in Sarajevo

Education: D.Chem., 1929, Czechoslovakia Institute of Technology

Major contributions: Synthesized adamantane and sulfanilamide; work in alkaloids; elucidated structures for nonactin, boromycin, ferrioxamins, and rifamycins; synthesized medium-sized ring compounds from dicarboxylic acid esters by acyloin condensation

Major prizes: 1975 Nobel Prize in Chemistry; 1969 ACS Roger Adams Award in Organic Chemistry

John Francis Queeny

Aug. 17, 1859–March 19, 1933; born in Chicago

Education: Six years of public school

Major contributions: Founded Monsanto in 1901; first U.S. company to produce saccharin, at a time when German chemical companies were the only commercial source; commercialized a breakthrough in the 1920s of the manufacture of sulfuric acid with a vanadium catalyst instead of the then-usual and expensive platinum catalyst

John D. Roberts

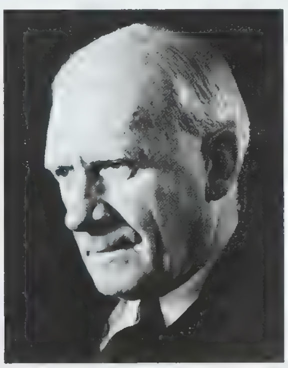
Born June 8, 1918, in Los Angeles

Current affiliation: California Institute of Technology

Education: A.B., 1941; Ph.D., chemistry, 1944; both from the University of California, Los Angeles

Major contributions: Mechanisms of carbocationic and aromatic displacement (benzyne) reactions; chemistry of small-ring compounds; substituent effects on chemical reactivity; molecular orbital calculations; applications of nuclear (especially carbon-13 and nitrogen-15) magnetic resonance spectroscopy to organic chemistry, bioorganic chemistry, and biochemistry

Major prizes: 1987 Priestley Medal; 1989 Welch Award in Chemistry; 1994 ACS Arthur C. Cope Award; member, National Academy of Sciences



Robert Robinson

Sept. 13, 1885–Feb. 8, 1975; born near Chesterfield, Derbyshire, England

Education: Bachelor's degree, 1905; Ph.D., 1909; both from the University of Manchester

Major contributions: Electronic theory of organic reaction mechanisms; total synthesis of natural products, especially alkaloids and steroids; theory of alkaloid biogenesis; structural elucidation of penicillin

Major prizes: 1947 Nobel Prize in Chemistry; 1953 Priestley Medal; fellow, Royal Society of Chemistry; foreign member, National Academy of Sciences

"'May you live in interesting times', says an old Chinese malediction. These are indeed interesting times for chemistry. Some people consider this a curse, but it is really an opportunity."

Ronald Breslow

C&EN's TOP 75

Glenn T. Seaborg

Born April 19, 1912, in Ishpeming, Mich.

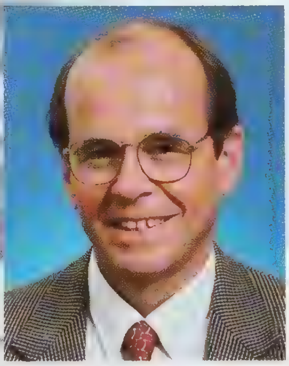
Current affiliation: University of California, Berkeley

Education: A.B., 1934, University of California, Los Angeles; Ph.D., chemistry, 1937, University of California, Berkeley

Major contributions: One of the discoverers of plutonium (plutonium-238 and plutonium-239) and headed the Manhattan Project group that devised the chemical extraction processes used in its production; codiscovered nine other transuranium elements, including element 106, seaborgium

Major prizes: 1951 Nobel Prize in Chemistry; 1979 Priestley Medal; 1991 National Medal of Science; 1994 ACS George C. Pimentel Award in Chemical Education; member, National Academy of Sciences

Dorothy Crowfoot Hodgkin



Karl Barry Sharpless

Born April 28, 1941, in Philadelphia

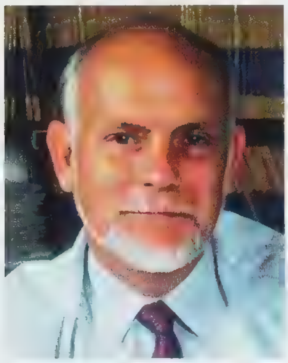
Current affiliation: Scripps Research Institute, La Jolla, Calif.

Education: A.B, 1963, Dartmouth College; Ph.D., organic chemistry, 1968, Stanford University

Major contributions: Discovery and development of many widely used catalytic oxidation processes, notably first general methods for stereoselective oxidation—the Sharpless reactions for the asymmetric epoxidation, dihydroxylation, and aminohydroxylation of olefins

Major prizes: 1983 ACS Award for Creative Organic Synthesis; 1991 Scheele Medal, Sweden;

1992 ACS Arthur C. Cope Award; 1993 Tetrahedron Prize for Creativity in Organic Synthesis; member, National Academy of Sciences



Richard E. Smalley

Born June 6, 1943, in Akron, Ohio

Current affiliation: Rice University, Houston

Education: B.S., 1964, University of Michigan, Ann Arbor; M.A., 1971, Princeton University; Ph.D., 1973, Princeton University

Major contributions: Pioneered advances in development of supersonic beam laser spectroscopy, super-cold pulsed beams, and laser-driven sources of free radicals, triplets, and metal and semiconductor cluster beams; discovered and characterized fullerenes, the third elemental form of carbon; first to generate fullerenes with metals trapped inside carbon cage; studies of carbon nanotubes

Major prizes: 1996 Nobel Prize in Chemistry; 1991 ACS Irving Langmuir Prize in Chemical Physics; 1992 Welch Award in Chemistry; 1993 William H. Nichols Medal; member, National Academy of Sciences

Hermann Staudinger

March 23, 1881–Sept. 9, 1965; born in Worms, Germany

Education: University of Halle, Germany

Major contributions: Principles of macromolecular chemistry; fundamental studies of polystyrene, polyesters, polyamides, vinyl amides,

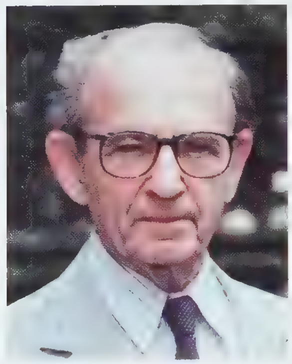
C&EN's TOP 75

and amino plastics, which laid the foundation for the giant plastics industry today; discovery of ketene

Major prizes: 1953 Nobel Prize in Chemistry

"Along the way, we came upon various points of interest, which invited us to linger a while. Ours, like all such rambling tours, possesses that which comes from knowing that the landscape spread out before us will be opened to view, not by intention, but by chance and surprise."

Georg F. K. Wittig



Gilbert Stork

Born Dec. 31, 1921, in Brussels, Belgium

Current affiliation: Columbia University

Education: B.S., 1942, University of Florida; Ph.D., chemistry, 1945, University of Wisconsin

Major contributions: Enamine alkylation and acylation; metallo-enamine alkylation; theory of concerted polyene cyclization; regiospecific enolate formulation and kinetic trapping; vinyl radical cyclization; radical holoacetal cyclization in control of regio- and stereochemistry; temporary silicon connection in stereo- and regiocontrol; first stereorational synthesis (cantharidin in 1951)

Major prizes: 1980 ACS Arthur C. Cope Award; 1983 National Medal of Science; 1993 Welch Prize in Chemistry; 1996 Wolf Prize in Chemistry; member, National Academy of Sciences

Henry Taube

Born Nov. 30, 1915, in Neudork, Saskatchewan

Current affiliation: Stanford University

Education: B.Sc., 1935, University of Saskatchewan; Ph.D., 1940, University of California, Berkeley

Major contributions: First determination of the solvation number of cations; correlation of substitution lability of metal complexes with electronic structure; intimate mechanisms of electron transfer in chemical reactions; systematic study of mixed-valence molecules and of back-bonding in relation to properties of metal complexes

Major prizes: 1983 Nobel Prize in Chemistry; 1983 Welch Award in Chemistry; 1985 Priestley Medal; 1985 National Medal of Science; member, National Academy of Sciences

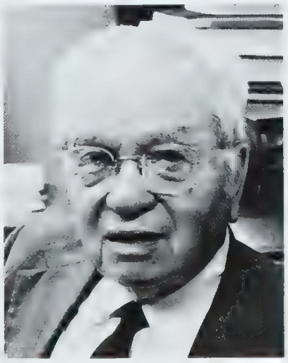
Max Tishler

Oct. 30, 1906–March 18, 1989; born in Boston

Education: Bachelor's degree, 1928, Tufts University; Ph.D., chemistry, 1934, Harvard University

Major contributions: Worked as an industrial chemist at Merck & Co. for 33 years and developed antibiotics, including actinomycin and streptomycin; facilitated commercial production of cortical steroids; synthesized vitamin A and riboflavin; led the Merck team that developed a production process for penicillin during World War II

Major prizes: 1970 Priestley Medal; 1987 National Medal of Science



Harold Clayton Urey

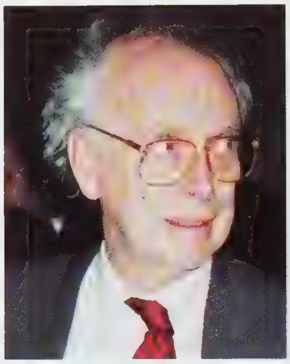
April 29, 1893–Jan. 5, 1981; born in Walkerton, Ind.

Education: B.S., 1917, University of Montana; Ph.D., chemistry, 1923, University of California, Berkeley

Major contributions: Discovery of deuterium; isotope separation

Major prizes: 1934 Nobel Prize in Chemistry;

1964 National Medal of Science; 1973 Priestley Medal; member, National Academy of Sciences



James Dewey Watson

Born April 6, 1928, in Chicago

Current affiliation: Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y.

Education: B.S., 1947, University of Chicago; Ph.D., 1950, Indiana University

Major contributions: Determined structure of DNA; DNA-protein interactions; role of RNA in protein synthesis

Major prizes: 1962 Nobel Prize in Physiology or Medicine; 1977 Presidential Medal of Freedom; member, National Academy of Sciences

Frank H. Westheimer

Born Jan. 15, 1912, in Baltimore

Current affiliation: Harvard University

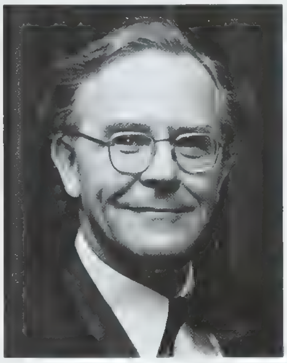
Education: A.B., 1932, Dartmouth College; M.A., 1933, Harvard University; Ph.D., chemistry, 1935, Harvard University

Major contributions: Calculation of electrostatic effects in chemistry; molecular mechanics; mechanism of chromic acid oxidations; metal-ion and enzymatic decarboxylations; direct and stereospecific transfer of hydrogen in biochemical oxidation-reduction; pseudorotation in hydrolysis of phosphate esters; invention of photoaffinity labeling

Major prizes: 1980 National Academy of Sciences Award in the Chemical Sciences; 1982

C&EN's TOP 75

ACS Arthur C. Cope Award; 1986 National Medal of Science; 1988 Priestley Medal; member, National Academy of Sciences



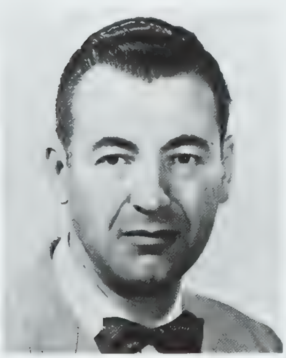
Geoffrey Wilkinson

July 14, 1921–Sept. 26, 1996; born in Todmorden, England

Education: B.Sc., 1941; Ph.D., 1946; both from Imperial College, London

Major contributions: Chemistry of metallocenes; chemistry of phosphorus halides, fluxional compounds, rhenium, rhodium, and ruthenium; chemistry of complex hydrides; mechanism of homogeneous catalytic reactions

Major prizes: 1973 Nobel Prize in Chemistry; fellow, Royal Society; foreign associate, National Academy of Sciences



Saul Winstein

Oct. 8, 1912–Nov. 23, 1969; born in Montreal, Quebec

Education: A.B., 1934, University of California, Los Angeles; M.A., 1935, University of California, Los Angeles; Ph.D., 1938, California Institute of Technology

Major contributions: Mechanisms of organic reactions; physical organic chemistry; ion pairs; homoconjugation; homoaromaticity

Major prizes: 1970 National Medal of Science (awarded posthumously); member, National Academy of Sciences

"Conquering high, remote mountains—inspiring—but of questionable significance to most of us. I have kept growing my little acorns into tall oak trees."

Herbert C. Brown

Georg F. K. Wittig

June 16, 1897–Aug. 26, 1987; born in Berlin, Germany

Education: Ph.D., 1923, University of Marburg/Lahn, Germany

Major contributions: Wittig reaction for conversion of C=O to C=C, which is used to make β-carotene, steroids, juvenile hormones, and pheromones, and some prostaglandins and vitamins

Major prizes: 1979 Nobel Prize in Chemistry

Robert Burns Woodward

April 10, 1917–July 8, 1979; born in Boston

Education: Bachelor's degree, 1936; Ph.D., 1937; both from Massachusetts Institute of Technology

Major contributions: Total synthesis of complex natural products, including vitamin B-12; organic structure determination; synthetic methods; biogenetic theory; conservation of orbital symmetry

Major prizes: 1965 Nobel Prize in Chemistry; 1964 National Medal of Science; 1973 ACS Arthur C. Cope Award; member, National Academy of Sciences

Rosalyn Sussman Yalow

Born July 19, 1921, in New York City

Current affiliation: Veterans Administration Hospital, Bronx, N.Y.

Education: A.B., Hunter College, 1941; Ph.D., 1945, University of Illinois, Urbana

Major contributions: Developed technique of radioimmunoassay

Major prizes: 1977 Nobel Prize in Physiology or Medicine

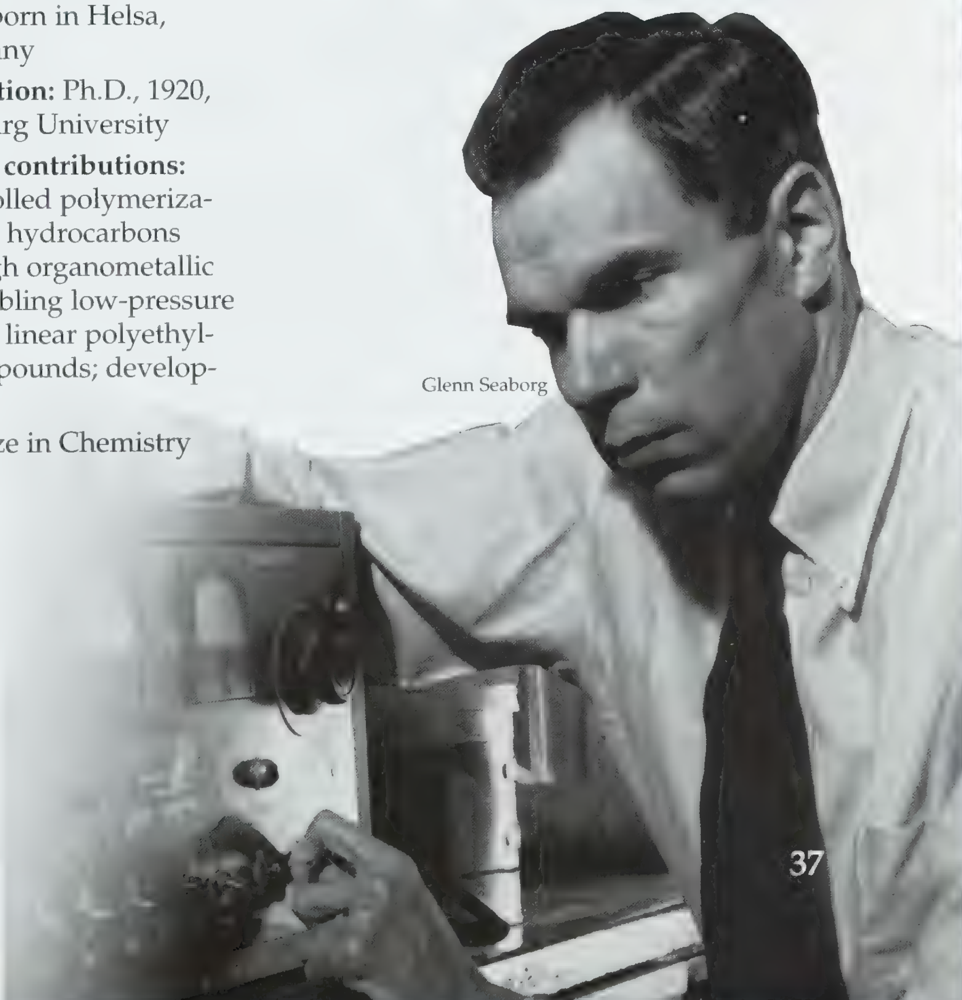
Karl Ziegler

Nov. 26, 1898–Aug. 11, 1973; born in Helsa, Germany

Education: Ph.D., 1920, Marburg University

Major contributions: Controlled polymerization of hydrocarbons through organometallic catalysts; catalytic system enabling low-pressure polymerization of ethylene to linear polyethylene; chemistry of carbon compounds; development of plastics

Major prizes: 1963 Nobel Prize in Chemistry



Glenn Seaborg

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The Nobel Foundation Web site, http://www.nobel.se/, and its mirror site, http://nobel.sdsc.edu/, have biographies of many Nobel Laureates.

Search the Internet using individual names.

Chemical Heritage Foundation
315 Chestnut St.
Philadelphia, PA 19106-2702
Phone: (215) 925-2222
Fax: (215) 925-1954
Internet: www.chemheritage.org

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Sylvia A. Ware, Director, Education Division
Madeleine Jacobs, Editor-in-chief, Chemical & Engineering News
Diana Slade, Assistant Editor, Chemical & Engineering News

A C S

Scientific discoveries are converging with 'Star Wars'

Page 8

Cue
YOUR ENTERTAINMENT GUIDE

Spanish novelist fences with splendor in new 'Master'

Book review, page 13

SUNDAY, JUNE 6, 1999 | MILWAUKEE JOURNAL SENTINEL | SECTION E

Art collector puts on his detective cap

By James Auer
Journal Sentinel art critic

Alfred Bader isn't exactly a submissive man. Indeed, he delights in describing himself as an "ornery cuss."

Still, nothing in his five-plus decades as a chemist, industrialist (he founded Aldrich Chemical Co., now part of Sigma Aldrich Corp.), art collector and gallery owner quite prepared him for the battle he has waged for the last 4½ years.

It has involved a mysterious, as-yet unidentified Moroccan scam artist who may or may not be a drug dealer; a personable Dutch angel of mercy who leads a Boy Scout troop; polite but uncommunicative Amsterdam police officers; national laws governing lost and stolen property; and three kidnapped Old Masters, one of which still eludes Bader's trans-oceanic grasp.

As the 75-year-old chemist-collector tells it, it's a perfect three-act morality play with a beginning, a middle, and – at least as of now – an incomplete ending.

"I may have to go to court," the soft-spoken connoisseur sighed during an interview in his picture-lined office at Alfred Bader Fine Art, a by-appointment-only gallery tucked away in the Astor Hotel, 924 E. Juneau Ave

Bader, characteristically, is not giving up. Struggle and persistence are part of his makeup – and his personal history

A native of Austria, he escaped the Nazis as a teenager and came to the New World. In Canada, he acquired an education at Queens University. In the United States, he built both an industrial empire and an enviable art collection

Quick Hands

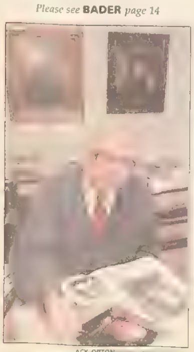
The story of a small – and elusive – part of that collection started on Nov. 12, 1994

Bader and his wife, Isabel, had arrived at the central railroad station in Amsterdam and were preparing to take a tram to their hotel. Later in the week, they intended to journey on to The Hague, where they would be showing three small but choice 17th-century artworks to experts at the Netherlands Institute for Art History, familiarly known as the RKD

The smallest of the artworks, all three of which were safely stashed away in Alfred's ample briefcase, was a sketch of a man. Bader suspected it was from the hand of Gonzales Coques, a skilled portraitist who had flourished in Antwerp, Belgium, around 1635. He had purchased it at Sotheby's in London the previous July

The other two works, both on wooden panels, he had acquired from London dealers the day before One depicted Rembrandt's mother, the other was titled, appropriately, "Portrait of a Man." Both begged for research and were potentially valuable

Please see BADER page 14



ICK ORTON

Alfred Bader has relentlessly pursued his stolen paintings.

Wired for sound

Get set: The Internet is ready to change the way many of us listen to music

By Gemma Tarlach
of the Journal Sentinel staff

Forget about Y2K hype. The weird acronym that might just change your life is MP3

MP3 is the leader among a host of new Internet-based technologies that are poised to revolutionize how you listen to music, how you purchase music – and even what music you listen to

And you don't have to be a tech-head to do it.

"It's like we've discovered this new continent, and everyone's looking to get their share of it," said Ron Richardson, media-ventures managing editor for Spin magazine and its sister publications Vibe and Blaze

Overseeing the magazines' Web sites, Richardson has followed the rise of MP3 and other Web music breakthroughs. "The revolution is here. It will take a while for it to hit everyone... but I don't see anyone losing."

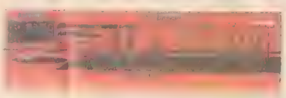
Musicians and fans alike are aquiver over emerging Web music technologies such as MP3 because it gives them greater accessibility to each other. Bands don't need a record contract to post songs on the Internet and get global exposure; listeners don't have to wait until the music they want to hear turns up at the local record store or on a radio station's playlist; and much of what's out there on the Net, at least for now, is free of charge

"If it's 3 a.m. in the morning and you can't sleep because you have a song stuck in your head, you can now go online and get that song," said Lorna Brown, multimedia sound guide for the Web-based information network, *About.com.*

There are some downsides to the new cyber-music: For fans, depending on their computer's configuration, download time can be lengthy, and options for playing the music on a portable Walkman-type device remain limited. For musicians, particularly established acts, pirated MP3s can cut into their earnings.

To hear the record companies talk, MP3 is the equivalent of an asteroid smacking into

Please see NET page 6



Users can customize MP3 software with a wide variety of "skins," or virtual faceplates, which can be downloaded from sites such as *www.winamp.com.*

CAROLYN RYAN/

Tonys give but a faint nod to 'small-town' Broadway

By Ben Brantley
New York Times News Service

New York – When did Broadway become the provinces?

The suspicion has been hovering for several decades now that the once-sophisticated mecca of American theater is really just a mall in Squaresville: a forum for automated theme park shows, with doses of high culture provided by visitors from more adventurous places

All the same, when the Tony Award nominations were announced last month, they seemed to offer especially disheartening confirmation of the idea, giving off what Lorenz Hart once described as "the faint aroma of performing seals."

It's not that there won't be things to celebrate at the Gershwin Theater tonight when the awards are handed out. (The live telecast will begin at 7 p.m. Milwaukee time on PBS for one hour, followed by two hours on CBS.)

This was, after all, a season in which the straight drama, unembellished by song and dance or eye-numbing special effects, reasserted itself as a potent box-office contender on Broadway, at least when propelled by the power of a known star.

And within that context, majestic instances of a breed of purely theatrical performance – overblown but dazzling, and nothing that could be contained by a film or television screen – flourished, testimony to stage acting as an art with its own transcendent rules, from Brian Dennehy and Elizabeth Franz in "Death of a Salesman" to Zoe Wanamaker in "Electra" and Kevin Spacey in "The Iceman Cometh."

Still, cast your eyes over the list of nominations in non-musical categories, and it's like reading a series of thank-you notes from the Colonies to their mother country, Great Britain, for graciously exporting its talent.

As for musicals, one can only shudder at the lineup of misfired, pandering revivals and bland, sanitized revues that suggest nightmares of elevator music assuming physical forms

Three plays, all imports and all still running, towered over Broadway this season as examples of how theater can move, stir and unsettle in a way that no other art form can. It

Please see THEATER page 4

CUE this week

A working mom

Mia Farrow balances her acting career with parenting her large brood of children.
MONDAY

Chameleon man

Punk, country, symphonic – there's almost no musical color that Elvis Costello hasn't taken on
TUESDAY

'Moon' over Milwaukee

The Asian Moon Festival brings a continent of sights, sounds and cuisine to the lakefront.
WEDNESDAY

The Dalai Lama's friends

The Beastie Boys, Blondie and Eddie Vedder top the bill of the Tibetan Freedom Concert.
THURSDAY

Urban pleasures

We suggest five days of fun in Milwaukee that will take you from breakfast outdoors to Jazz in the Park.
FRIDAY

SUMMER GUIDE

RiverSplash!

TODAY

Midwest Express Kid's Day presented by Channel 24 and WB 18 at Pere Marquette Park.

Cafe Vecchio Mondo

The Harp Irish Pub

Midwest Express Landing

Asian Moon Festival

Friday through next Sunday at Maier Festival Park. Hours: 5 to 11 p.m. Friday; 11 a.m. to 11 p.m. Saturday; 11 a.m. to 7 p.m. next Sunday. Advance tickets at $5 can be ordered by calling 821-9829. Admission at the gate: $8 for adults; children 12 and under free. Seniors with ID and persons with disabilities will be admitted free between 5 and 7 p.m. Friday. For festival information, visit the Web site www.asianmoon.org. Here are some highlights

FRIDAY

Miller Stage: 5:15 p.m., Windpipe Musicians & Hmong and Laotian Dances, Hmong American Friendship

C.J. Chenier will perform at Cajunfest, to be held Friday through next Sunday at

Harley-Davidson Roadhouse:

SATURDAY

New York Life Mid-Gate Stage:

Cajunfest

Friday through next Sunday at State Fair Park, 8100 W. Greenfield Ave., West Allis. Hours: 5 to 11:30 p.m. Friday; 10 a.m. to 11:30 p.m. Saturday; 10 a.m. to 9 p.m. next Sunday. On Saturday and Sunday, festival goers can receive $2 off the admission by donating two non-perishable food items to the Hunger Task Force of Milwaukee. Tickets are available at southeastern Wisconsin Kohl's Stores and Starship Stores. Admission: Adults, $5; seniors and teenagers 13 to 17 years old, $4; children 12 and under admitted free. For information call (414) 476-7303 or visit the Web site at www.cajunfest.org. Here are some highlights

FRIDAY

Budweiser Mardi Gras Tent: 7:15 p.m., Hat Trick

Sprecher Beer Garden: 6:45 p.m. Rockerfellers

SATURDAY

Sprecher Beer Garden: 10 a.m., Maker Brothers; The Convertibles; 7 p.m., Shirley Johnson

Budweiser Mardi Gras Tent: 4:30 p.m., Terry Frank & Bone Deluxe (featuring Blues Harp Jimmy); 9:15 p.m., C.J. Chenier and the Red Hot Louisiana Band

NEXT SUNDAY

Sprecher Beer Garden: 11:30 a.m. John the Conqueroo, 4:45 p.m., Mount Olive

Budweiser Mardi Gras Tent: Noon Big Nick & the Cydecos; 5 p.m. Pork and the Havana Ducks

Shermanfest '99

Saturday and next Sunday at Sherman Park, 3000 N. Sherman Blvd. Hours: 10 a.m. to 9 p.m. Saturday; 10 a.m. to 8 p.m. next Sunday. Free admission. For information, call 444-9803

SATURDAY

NEXT SUNDAY

Noon, Devil in the Woodpile, 1:30 p.m. Terry Frank & Bone Deluxe, 3 p.m., Aaron Moore & The Chicago Blues Band 4:30 p.m., Eddie Shaw & The Wolf Gang; 6:30 p.m. Willie Kent and the Gents with Miss Bonnie Lee and Miss Patricia Scott

Rainbow Summer

Free outdoor concert series weekdays through Aug. 28 at the Peck Pavilion at the Marcus Center, 929 N. Water St.

Tuesday: Milwaukee's All Star Rainbow Coalition, noon and 7 p.m.

Wednesday: Kids' Day: Cheney & Mills, noon

Thursday: Big Nick and the Cydecos, noon

Friday: Ko-Thi Dance Company, noon

Jazz in the Park

Free Thursday evening concerts at Cathedral Square Park, Jackson and Wells streets in downtown Milwaukee. Concerts begin at 6:30 p.m. For information, call 271-1416.

Thursday: Greg Koch Koalition

June 17: Wisconsin Conservatory Jazz Ensemble

June 24: Streetlife with Warren Wiegratz

What's Ahead

A look at other festivals coming up soon. Watch the daily Cue and Weekend Cue sections for details about these and other upcoming events

June 11: Senior Fest, State Fair Park, West Allis

June 17-20: West Allis Western Days, State Fair Park, West Allis

June 18-20: Wonago Rodeo, State Fair Park

June 18-20: Polish Fest, Maier Festival Park

June 18-20: Lakefront Festival of the Arts, Grounds just north of the Milwaukee Art Museum

June 24-July 4: Summerfest, Maier Festival Park

June 26: Octagon Art Fair, Octagon Farms, Grafton

June 26-Aug. 22: Bristol Renaissance Faire

June 26-27: Strawberry Festival, Historic district along Washington Ave., Cedarburg

June 26: Bavarian Volksfest, Old Heidelberg Park

June 27: Cathedral Avenue Arts & Blues

July 6-11: Circus Parade Week, Veterans Park at the lakefront

SHOWGUIDE

Music

Leonard Sorkin Memorial Violin Competition.

Violin Recital.

Laura Snyder.

Fine Arts Quartet.

Summer Evenings of Jewish Music.

Organ Recital.

Milwaukee Symphony Pops.

Dance

Danceworks Performance Group.

Theater

Bialystock & Bloom

Broadway Baby.

Broom Street Theater

ComedySportz.

Dale Gutzman Productions

Inertia Ensemble

Lakeland Players

Elkhorn

Melanec's Wheelhouse Dinner Theatre

Sunset Playhouse.

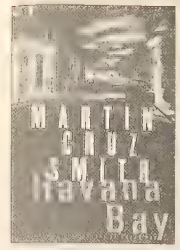
Art

Anderson Arts Center. 42nd Annual Juried Exhibit, Racine Art Guild

Dean Jensen Gallery.

Radiant Light Galleries.

Books



Arkady Renko on the case in 'Havana Bay'

Havana Bay. *By Martin Cruz Smith. Random House. 329 pages. $25.95*

By Dorman T. Shindler
Special to the Journal Sentinel

The gift that sets Martin Cruz Smith apart from other writers of mystery and suspense is his ability to guide readers into worlds and cultures that may have been heretofore unknown to them: from gypsies ("Gypsy in Amber") to North American Indians ("Nightwing," "Stallion Gate") to 19th-century Welsh coal miners ("Rose") and pre-glasnost Russia ("Gorky Park").

With "Havana Bay," Smith visits modern-day Cuba and once again opens up a secretive, closed-door society. What's more, "Havana Bay" is his best Arkady Renko novel since "Gorky Park." High praise when you consider the quality of other books in the series ("Polar Star," "Red Square").

Still reeling from a personal tragedy, Detective Renko is sent to Cuba to identify the body of an accident victim — a Russian diplomat. The catch is that the victim is one Sergei Pribluda, one-time nemesis and, later, begrudging friend of Renko's.

From the opening chapter, Smith proves himself still capable of catching the reader off guard. He describes a scene in which the body (having floated in the sea for days) literally falls apart when being recovered. Such gruesome scenes are balanced by Smith's meticulous research into Cuban forensics and foreign police procedures, not to mention his love of language.

Smith describes Renko's first impression of Detective Ofelia Osorio, a woman who will become his only ally: "Her features were delicate and sharply cut, dark eyes made darker with suspicion as if she were an apprentice devil handed a tricky soul."

From the start, Renko senses something amiss with the death of his friend. But the Cuban police, especially Sergeant Luna, want Renko to identify the body and take it back to Russia on the first available flight. When Renko stalls, he finds himself a target for murder

His efforts to investigate are hampered by a suspicious government — in Cuba, Renko discovers, Russians are as hated as Americans — and a rogue group of police led by the murderous Luna. Turning to Osorio for help, Renko uncovers a plot that seems to be leading to an assassination

As revealed by Smith, modern-day Cuba is "the first place where time does not exist." Cars, clothes, music, even the people, seem to be trapped in a bygone era. Communism exists comfortably alongside exotic religions like Santeria. And Renko's de facto partner, Osorio, proves to be every bit as interesting, resourceful and enigmatic as Arkady

The two detectives make perfect foils. Arkady's stoic and reserved manner is juxtaposed nicely with Ofelia's passionate, quick-tempered personality.

The desire for justice and insatiable curiosity are the common threads that bind them.

Like Walter Mosley, Martin Cruz Smith writes novels which transcend their given genre while evoking a particular time and place with unerring precision. Filled with Smith's trademark twists of plot and eye-opening revelations about Cuba, "Havana Bay" is a first-rate thriller

Dorman T. Shindler is a freelance writer from Missouri

Smart and funny Jane just gets better as she goes along in 'Girls' Guide'

Girls' Guide to Hunting and Fishing. *Viking. 274 pages $23.95*

By Meg Kissinger
of the Journal Sentinel staff

A good man is hard to find.

Flannery O'Connor already has dibs on that title. Otherwise, it would have been a swell one for Melissa Banks' smart new book, "Girls' Guide to Hunting and Fishing."

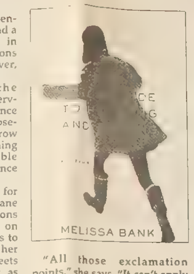
Banks, 38, an ad copy writer whose work has appeared in The New Yorker, Zoetrope and National Public Radio's Selected Short Stories, has strung together an engaging collection of seven pithy coming-of-age stories. Don't be fooled by the breezy tone of the title. Banks tackles all manner of heavy stuff here — alcoholism, cancer, death, infidelity, impotency and the biggest i-word of all, insecurity. Especially insecurity.

For all the angst there, Banks takes on the world with such enthusiasm, self-deprecation and a tongue so firmly planted in cheek that her observations come across as sweetly clever, not bitter

She begins with the 14-year-old Jane drolly observing her older brother's romance with an older woman. In subsequent stories, we see Jane grow up, struggle as a publishing house editor and stumble through one failed romance after another

She saves her best yarn for last, the title story where Jane has imaginary conversations with the authors of a book on how to woo men. She gropes to hang on to the man of her dreams, a cartoonist she meets at her best friend's wedding, as her pretend advisers offer up such counsel as "Keep him guessing!", "Be mysterious", "Say yes to everything you're invited to!" and "Let him pay!"

Her friend, Donna, is suspicious



"All those exclamation points," she says. "It can't apply to New York."

The requisite hoodwinkery and formality involved in bagging the big game has Jane confused. When her brother calls to invite her to a square dance and announces that it is a singles event, she immediately thinks of individually wrapped American cheese slices. Still, she accepts. Remember, "Say yes to everything you're invited to!"

Francis Ford Coppola has hired Banks to write the screenplay, so look for it soon as a major motion picture near you.

Banks peppers her prose with irony. "I was shy, so I talked too much," she recalls of meeting her future boyfriend, a man 28 years her senior. When he tells her, "You've grown up, honey," she confesses that it felt good to hear it.

"I thought maybe he was right. Then it occurred to me that if I really had grown up I wouldn't want to be told."

A girls' guide, indeed! This girl is all woman.

Melissa Banks will read from her debut novel at 7 p.m. on Tuesday at Harry W. Schwartz Bookshop, 4093 N Oakland Ave., Shorewood

Honor, intrigue sharpen intellectual thriller

The Fencing Master. *By Arturo Perez-Reverte. Translated from the Spanish by Margaret Jull Costa. Harcourt Brace. 244 pages. $24*

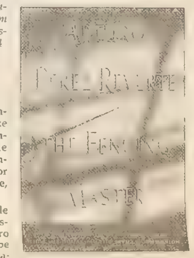
By David Walton
Special to the Journal Sentinel

The scene is Madrid, the summer of 1868. Rumors circulate the capitol of an impending insurrection that will topple Queen Isabelle II, whose scandals have become too much for the politicians, if not the people, to bear

Don Jaime Astarloa, the title character of "The Fencing Master," the fourth of Spain's Arturo Perez-Reverte's novels to be translated into English, is Madrid's greatest fencing master, a gentleman of the old school who, now in his 50s and white-haired, earns a threadbare living giving lessons to sons of the nobility. In this age of the pistol, Don Jaime is a throwback, a man of honor who has devoted his life to discovering the perfect fencing move: the "unstoppable thrust."

Perez-Reverte, the author of "The Flanders Panel," "The Club Dumas,' and "The Seville Communion," is a former TV journalist who is now published in 30 countries in 19 different languages and has become one of the world's most popular novelists

Often compared to Umberto Eco, Perez-Reverte writes what can be called intellectual thrillers — a kind of suspense novel that's founded upon a concept of art, philosophy, or in this case, fencing, and resolved along the logic of that concept. Meticulously researched, his novels are polished, erudite, cosmopolitan, but never plodding or stodgy. Certainly in the case of "The Fencing Master," never plodding



Don Jaime receives an invitation to call upon a woman he assumes will be the mother of a prospective student — Dona Adela de Oreto, who instead proves to be a beautiful young woman with a tiny scar at the corner of her mouth and an unusual request. Dona de Oreto offers to pay Don Jaime twice his normal fee to teach her a secret thrust he is reputed to know, said to be impossible to parry.

At first Don Jaime refuses to accept a woman as his student. But Adela de Oreto proves persistent, and surprisingly knowledgeable about fencing, and eventually Don Jaime consents. He finds her a skilled fencer, fearless and determined. And soon, she's begun to awaken other feelings in him — feelings the aging Don Jaime hasn't felt for a woman in many years.

From this beginning, there evolves an intricate plot of moves and countermoves similar to the pattern of a fencing match, a tangled pattern of high politics and low betrayals that eventually, as the reader knows all along that it must, draws Don Jaime away from dusty treatises and arcane debates on the art of fencing and onto the floor of battle.

This is becoming quite a spring for Perez-Reverte, with a tour of eight American cities

> Meticulously researched, Perez-Reverte's novels are polished, erudite, cosmopolitan, *but never plodding or stodgy.*

scheduled for June, the paperback release of "The Seville Communion," the release of "The Ninth Gate" and the film version of "The Club Dumas" directed by Roman Polanski and starring Johnny Depp as the rare book sleuth Lucas Corso.

David Walton, who lives in Pittsburgh teaches writing and literature

Frenetic satire on today's urban life at heart of long and winding 'Century'

By Anne Stephenson
Arizona Republic

Turn of the Century. *By Kurt Andersen. Random House. 659 pages. $24.95.*

You're going to read lots of reviews of this book, an inordinate number given that it's a 659-page first novel. Kurt Andersen is, as they say, connected, and at the other end of the tether are people any first novelist would love to know.

He is, at present, a columnist for The New Yorker.

In previous incarnations, he was co-founder and editor of Spy magazine, editor in chief of New York magazine and a producer of network television shows.

Before that, he had the foresight to work for several years on the staff of Time magazine, where his book has already received a full-page spread (Annie Proulx and Peter Matthiessen took what was left).

Does the book work for its living?

As a novel, no. As a manic satire on urban life as we know it (or will know it next year, which is when Andersen's story begins), yes, sort of.

At the center of its story are George Mactier and Lizzie Zimbalist, who have been married 10 years and have three kids, a Land Cruiser, dueling cell phones and a life that is blurry in its pace and trend-hopping zeal. George is a former journalist who now produces a television show called "NARCS," a drama that dabbles in "real" life (it is, George thinks, "extremely cool television"). Lizzie is a software entrepreneur

The plot is not easy to describe, but that's not the novel's strong point anyway. What carries you along — and it's best to take it in doses, to avoid overkill — is Andersen's frenetic talent for skewering the shallow accoutrements of George and Lizzie's professional and personal lives, thereby reminding us of the deeper pleasures that have escaped them.

He does this so very well. He could have done it even better in a shorter book.

Shadows, Fire, Snow: The Life of Tina Modotti. *By Patricia Albers. Potter. 304 pages. $30*

She is known more for Edward Weston's photographs of her than for all of the photographs she made herself. After she died alone in a taxi cab at age 45, her death certificate listed her as a "housewife

Yet Tina Modotti was a remarkable woman — independent, impassioned both politically and artistically and surrounded by controversy

In addition to Weston, (she became his model and then his lover, her desire "fueled by the authority of his creative accomplishment"), she knew some of the most interesting people of her time, including Pablo Neruda (the title of this book is from his poem, "Tina Modotti is Dead") John Dos Passos, Diego Rivera and Frida Kahlo.

> Tina Modotti was a remarkable woman — independent and impassioned and surrounded by controversy

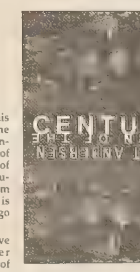
There have been other biographies of Modotti, but this is the best Patricia Albers had access to two trunkloads of material from the estate of Modotti's first "husband" — they posed as a married couple but were not — that included three dozen letters written by Modotti and 100 images made by her.

"In portraying her," Albers writes, "my endeavor has been to keep one hand upon the tattered objects in the trunks."

The result is a portrait of an enigmatic woman who has been called the best "unknown" photographer of this century.

Working at Play: A History of Vacations in the United States. *By Cindy S. Aron. Oxford. 261 pages. $35*

At early 19th century resorts, men were permitted to gamble only if there were no women



present, ladies and gentlemen swam in mineral springs at separate times, and everyone behaved impeccably. Back then, vacationing was the custom of an elite class looking for improved health. By World War II, it was a mass phenomenon

Cindy Aron traces this evolution, and looks at the struggle with which Americans face their vacations today (it's a love/hate thing — we want to take vacations but fear the consequences).

'More than just yearly rituals in which we connect with friends and family, vacations are exercises in self-definition," she writes. "In affording time away from the demands of everyday life, vacations disclose what people choose to do rather than are required to do."

This is as scholarly as a book about vacations can be, and well-planned — it's that time of year again.

Liberal ideas take precedence in too-narrow Reuss 'memoir'

When Government Was Good. Memories of a Life in Politics. *By Henry S. Reuss. The University of Wisconsin Press. 177 pages. $22.95.*

By Frank A. Aukofer
of the Journal Sentinel staff

This small volume is billed as a memoir, but it could easily be retitled "The Essential Guide to the Fertile Liberal Mind of Henry S. Reuss."

Though it contains some autobiographical reminiscences, this is Reuss at his most insistent. At the age of 87, when most men would be kicked back somewhere cozy, the former Milwaukee congressman is still promoting ideas, trying to change minds and seeking to influence events.

Reuss

He lives now in San Francisco, but is essentially a German-American Milwaukeean, of the old school of liberals and Socialists who espoused a clean and caring government that, at bottom, was dedicated to taking care of people.

Though Reuss had a patrician streak, and was comfortable in his long association with international bankers in dark pinstripes, he was equally at home in a seersucker suit and straw hat at a Fourth of July doll buggy parade in Gordon Park.

A Democrat, Reuss represented the 5th Congressional District for 28 years. Though a man of means, he was what one might describe as a "good liberal," with a populist streak dedicated to civil rights, environmental protection, cities, the outdoors, monetary and campaign finance reform and a brand of economics skewed toward ordinary folks and away from the rich and powerful.

He criticizes the home mortgage-interest tax deduction and the increase in the estate tax deduction as promoters of inequality. The former, he says, misallocates investment, steering it toward private mansions and away from productive plants and equipment.

Of the latter deduction, he argues that progressive income and estate taxes are the two great equalizers of the federal system. "We should be simplifying them and plugging loopholes, not systematically weakening them and thus creating greater inequality," he says.

Reuss describes "when government was good" as the two decades between 1948 and 1968. Interestingly, the latter date coincides with the first inaugural of President Richard M. Nixon. But many of the events he cites happened after 1968, including his own rise to influence as chairman of the congressional Joint Economic Committee and the House Banking Committee.

To win the latter job in 1975, Reuss toppled Texas populist Wright Patman in the caucus of House Democrats, effectively ending the long tradition of selecting chairmen strictly on seniority.

In his congressional career, Reuss promoted everything from getting the U.S. off the gold standard to the development of the Ice Age hiking trail through Wisconsin. He loved the outdoors and could out-hike many men half his age.

Always there have been the ideas: Merging the city and county governments of Milwaukee for efficiency; passage of a constitutional amendment to provide for special presidential and congressional elections in times of crisis like those of the Nixon and Clinton presidencies; and creative ways to use old laws for new purposes.

Given the subject, this book is disappointingly thin. In choosing, as always, to give prominence to ideas, Reuss tells us too little about himself.

Frank Aukofer is the Washington D.C. bureau chief for the Journal Sentinel

Author Henry S. Reuss will sign copies of his book after a 7 p.m. talk on June 22 at Harry W. Schwartz bookshop. 4093 Oakland Ave., Shorewood

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We suggest five days of fun in Milwaukee that will take you from breakfast outdoors to Jazz in the Park.
FRIDAY

SUMMERGUIDES

RiverSplash!

Continues today at six locations along the Milwaukee River between Kilbourn Ave. and Knapp St. Admission is free. Highlights include

TODAY

Midwest Express Kid's Day presented by Channel 24 and WB 18 at Pere Marquette Park: 11 a.m.-5 p.m. [illegible] slide and castle bounce [illegible] painting, roving puppets, clowns, costumed characters and helium balloons. [illegible] Theatre's production "Tales from the Nile" with Rosa Onama, 1 p.m., Betty Brinn Children's Museum's [illegible] and Miquel Sot[illegible] 4 p.m. [illegible] World Museum Fire and Ice Show.
Cafe Vecchio Mondo: 11 a.m. All-you-care-to-eat pancake brunch, $6
The Harp Irish Pub: 2 p.m. Big Nick and the Cydecos
Midwest Express Landing: 3 p.m.-5 p.m. Hyatt Regency Milwaukee Watercraft Freestyle show; 1 p.m., 4 p.m. Hyatt Regency Milwaukee Hydrofoil Stunt Show

Asian Moon Festival

Friday through next Sunday at Maier Festival Park. Hours: 5 to 11 p.m. Friday; 11 a.m. to 11 p.m. Saturday; 11 a.m. to 7 p.m. next Sunday. Advance tickets at $5 can be ordered by calling 821-9829. Admission at the gate: $8 for adults children 12 and under free. Seniors with ID and persons with disabilities will be admitted free between 5 and 7 p.m. Friday. For festival information, visit the Web site www.asianmoon.org. Here are some highlights

FRIDAY

Miller Stage: 5.15 p.m., Windpipe Musicians & Hmong and Laotian Dances, Hmong American Friendship

C.J. Chenier will perform at Cajunfest, to be held Friday through next Sunday at

A[illegible] 6 15 p.m., Non La Dance, Vietnamese Student Association of UWM 6 45 p.m. Paseo de Luna, 7 p.m., opening ceremony 7 45 p.m., fashion show 8 45 p.m. and an classical and folk dances [illegible] Cultural Society; 9 45 p.m. Tropical Heat Band
Harley-Davidson Roadhouse: 6 p.m., Club 29 Hmong Dancers; 6:30 p.m. Native Taiwanese Dance Troupe 7:30 p.m., Kalakriti Dance Company 8 30 p.m., Hale O Malo Polynesian Revue 9 30 p.m., Koom Srab, Hmong band singing Hmong and Laotian songs

SATURDAY

New York Life Mid-Gate Stage: 11 a.m., Kim Murley, music; 11:30 a.m. and 5:30 p.m., The Amazing Roloff, magician; 12:30 and 5 p.m., Kerry Leung, Chinese classical music; 1 p.m. Vietnamese Dragon Dance and Flower Dance, Vietnamese Students Association of Marquette University; 1:30 p.m., Two Lao Sweethearts, Laotian and Thai songs; 2 p.m., Native Taiwanese Dance Troupe, 3 p.m., Illusion's Angels, contemporary Hmong dances, 3:30 and 6.30 p.m., Hale O Malo Polynesian Dancers; 4 30 p.m., Bon-Odori interactive Japanese folk dancing with Mary Ohno; 7 p.m., Ras Dandiya, Indian stick dancing

Cajunfest

Friday through next Sunday at State Fair Park, 8100 W Greenfield Ave., West Allis Hours: 5 to 11 30 p.m. Friday; 10 a.m. to 11:30 p.m. Saturday, 10 a.m. to 9 p.m. next Sunday. On Saturday and Sunday, festival goers can receive $2 off their admission by donating two non-perishable food items to the Hunger Task Force of Milwaukee Tickets are available at southeastern Wisconsin Kohl's Stores and Starship Stores. Admission Adults, $5; seniors and teenagers 13 to 17 years old, $4; children 12 and under admitted free. For information call (414) 476-7303 or visit the Web site at www.cajunfest.org. Here are some highlights

FRIDAY

Budweiser Mardi Gras Tent: 7 15 p.m., Hat Trick

Sprecher Beer Garden: 6:45 p.m RockerFellers

SATURDAY

Sprecher Beer Garden: 10 a.m., Maker Brothers; The Convertibles; 7 p.m., Shirley Johnson

Budweiser Mardi Gras Tent: 4 30 p.m., Terry Frank & Bone Deluxe (featuring Blues Harp Jimmy); 9:15 p.m., C.J. Chenier and the Red Hot Louisiana Band

NEXT SUNDAY

Sprecher Beer Garden: 11:30 a.m John the Conqueroo; 4:45 p.m., Mount Olive

Budweiser Mardi Gras Tent: Noon Big Nick & the Cydecos; 5 p.m. Pork and the Havana Ducks

Shermanfest '99

Saturday and next Sunday at Sherman Park, 3000 N Sherman Blvd. Hours. 10 a.m. to 9 p.m. Saturday; 10 a.m. to 8 p.m. next Sunday. Free admission. For information, call 444-9803

SATURDAY

Noon E[illegible] N[illegible]den, 1:45 p.m., Jim Liban Blues Combo with special guest Stokes 3 30 p.m. [illegible] Ed & The Original Blues Imperials, 5 30 p.m. Howard Scott & The World Band with [illegible] Johnson & [illegible] Weathers by 7 30 p.m. Little Milton

NEXT SUNDAY

Noon Devil in the Woodpile 1 30 p.m. Terry Frank & Bone Deluxe 3 p.m. Aj[illegible] Moore & The Chicago Blues Band 4 30 p.m., Eddie Shaw & The Wolf Gang; 6:30 p.m. Willie Kent and the Gents with Miss Bonnie Lee and Miss Patricia Scott

Rainbow Summer

Free outdoor concert series weekdays through Aug. 28 at the Peck Pavilion at the Marcus Center, 929 N. Water St

Tuesday: Milwaukee's All Star Rainbow Coalition, noon and 7 p.m
Wednesday: Kids' Day: Cheney & Mills, noon
Thursday: Big Nick and the Cydecos, noon
Friday: Ko-Thi Dance Company, noon

Jazz in the Park

Free Thursday evening concerts at Cathedral Square Park, Jackson and Wells streets in downtown Milwaukee. Concerts begin at 6.30 p.m. For information, call 271-1416

Thursday: Greg Koch Koalition
June 17: Wisconsin Conservatory Jazz Ensemble
June 24 Streetlife with Warren Wiegratz

What's Ahead

A look at other festivals coming up soon. Watch the daily Cue and Weekend Cue sections for details about these and other upcoming events

June 11-[illegible] Fest, State Fair Park, West Allis
June 17-20 West Allis Western Days State Fair Park, West Allis
June 18-20 W[illegible] Rodeo State Fair Park, West Allis
June 18-20: Polish Fest Maier Festival Park
June 18-20: Lakefront Festival of the Arts Grounds just north of the Milwaukee Art Museum
June 24-July 4: Summerfest. Maier Festival Park
June 26: Octagon Art Fair Octagon Farms, Grafton
June 26-Aug. 22: Bristol Renaissance Faire
June 26-27 Strawberry Festival, Historic district along Washington Ave Cedarburg
June 26: Bavarian Volksfest Old Heidelberg Park
June 27: Garfield Avenue Arts & Blues Festival W Garfield Ave from N 5th to N 7th St
July 6-11: Circus Parade Week, Veterans Park at the lakefront

SHOWGUIDES

Music

Leonard Sorkin Memorial Violin Competition. Final round with Sherry Hong, Catherine Jang, John Patek, Rebekah Wolkstein 3 today, University of Wisconsin-Milwaukee School of the Arts Recital Hall, 2400 E. Kenwood Blvd

Violin Recital. Elaine Skorodin, with pianist Zoya Goldenberg-Makhlina. 3 today, Charles Allis Art Museum, 1801 N. Prospect Ave

Laura Snyder. Gospel singer (who is also a bass player in the Milwaukee Symphony) performs music from her new CD, "Precious Lord, Take My Hand"; with pianist Henry Wiens, cellist Jared Snyder and violinist Jenny Snyder. 6 today, Elmbrook Church, 777 S. Barker Road

Fine Arts Quartet. With guest violist James Creitz; Bruckner's Viola Quintet, Haydn's Quartet Opus 33 No. 3 ("Bird"), Schubert's Quartet Opus 29 on the Summer Evenings of Music Series. 7:30 tonight, University of Wisconsin-Milwaukee School of the Arts Recital Hall, 2400 E Kenwood Blvd

Summer Evenings of Jewish Music. Pianist Daniel Beliavsky, cantor Heather Feffer, violist Wendy Richman 7:30 Tuesday, Jewish Community Center Ritz Theater, 6255 N. Santa Monica Blvd, Whitefish Bay

Organ Recital. Phyllis Stringham plays a varied program, including a new piece written for her by Hugo Hartig, on the Music at 7 series 7 Tuesday, Carroll College Shattuck Auditorium, 100 N. East Ave., Waukesha

Milwaukee Symphony Pops. Conductor/trumpeter Doc Severinsen, fiddler Mark O'Connor. 8 Friday and Saturday, 7:30 next Sunday, Marcus Center Uihlein Hall, 929 N Water St

Dance

Danceworks Performance Group. Informal showing of works in progress 5:30 Friday, Studio 1661, 1661 N. Water St. (Northern Lights Building)

Theater

Bialystock & Bloom "Twelfth Night," 7:30 today and Wednesday-Thursday, 8 Friday-Saturday, to June 13 Studio Theatre, Broadway Theatre Center, 158 N Broadway

Broadway Baby "Lucky Stiff," 4 today, 7:30 Wednesday, 8 Friday-Saturday, to June 27 Dinner theater at 5132 W Mill Road

Broom Street Theater "69," 8 today. Madison

ComedySportz 6:30 today, 7:30 Wednesday (minor league show), 7:30 Thursday, 7:30 and 10 Friday, 3, 7:30 and 10 Saturday. 126 N. Jefferson St

Dale Gutzman Productions "Harry and Al," 2 today. Centennial Hall, Milwaukee Public Library, 733 N. 8th St

Inertia Ensemble "True Dreams of Annie Arbor," 8 Friday-Saturday, to June 27. Walker's Point Center for the Arts, 911 W National Ave

Lakeland Players. "The Music Man," 8 Friday-Saturday, to June 20 Walworth County Performing Arts Center, Elkhorn

Melanec's Wheelhouse Dinner Theatre "Murder Stalks the Reunion," 8 Friday-Saturday, to Aug. 28 2178 N Riverboat Road

Sunset Playhouse. "Moon Over Buffalo," 2 and 7 today, 8 Thursday-Friday, 6 and 9 Saturday. 800 Elm Grove Road, Elm Grove

Art

Anderson Arts Center. 42nd Annual Juried Exhibit, Racine Art Guild, also works by Donna Elliott, Thomas Kapheim, Florence Bern, Nancy Newcomb, others (to July 18); reception 1 30-4 today 131 66th St, Kenosha

Dean Jensen Gallery. Father Terence Fitzmaurice: The Millennium Paintings, also, Gerard Sendry: Visages (June 12-July 17); reception for Fitzmaurice, 1-4 Saturday, 759 N Water St

Radiant Light Galleries. Thomas Kinkade Touring Museum (11 a.m.-7 p.m. Saturday), 9724 W. Forest Home Ave, Hales Corners

Books

Smart and funny Jane just gets better as she goes along in 'Girls' Guide'

Girls' Guide to Hunting and Fishing. *Viking. 274 pages $23.95.*

By Meg Kissinger
of the Journal Sentinel staff

A good man is hard to find.

Flannery O'Connor already has dibs on that title. Otherwise, it would have been a swell one for Melissa Banks' smart new book, "Girls' Guide to Hunting and Fishing."

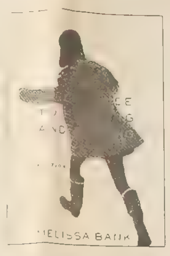
Banks, 38, an ad copy writer whose work has appeared in The New Yorker, Zoetrope and National Public Radio's Selected Short Stories, has strung together an engaging collection of seven pithy coming-of-age stories. Don't be fooled by the breezy tone of the title. Banks tackles all manner of heavy stuff here — alcoholism, cancer, death, infidelity, impotency and the biggest i-word of all, insecurity. Especially insecurity.

For all the angst there, Banks takes on the world with such enthusiasm, self-deprecation and a tongue so firmly planted in cheek that her observations come across as sweetly clever, not bitter.

She begins with the 14-year-old Jane drolly observing her older brother's romance with an older woman. In subsequent stories, we see Jane grow up, struggle as a publishing house editor and stumble through one failed romance after another.

She saves her best yarn for last, the title story where Jane has imaginary conversations with the authors of a book on how to woo men. She gropes to hang on to the man of her dreams, a cartoonist she meets at her best friend's wedding, as her pretend advisers offer up such counsel as "Keep him guessing!", "Be mysterious", "Say yes to everything you're invited to!" and "Let him pay!"

Her friend, Donna, is suspicious.



"All those exclamation points," she says. "It can't apply to New York."

The requisite hoodwinkery and formality involved in bagging the big game has Jane confused. When her brother calls to invite her to a square dance and announces that it is a singles event, she immediately thinks of individually wrapped American cheese slices. Still, she accepts. Remember, "Say yes to everything you're invited to!"

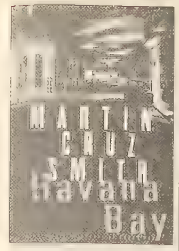
Francis Ford Coppola has hired Banks to write the screenplay, so look for it soon as a major motion picture near you.

Banks peppers her prose with irony. "I was shy, so I talked too much," she recalls of meeting her future boyfriend, a man 28 years her senior. When he tells her, "You've grown up, honey," she confesses that it felt good to hear it.

"I thought maybe he was right. Then it occurred to me that if I really had grown up I wouldn't want to be told."

A girls' guide, indeed! This girl is all woman.

Melissa Banks will read from her debut novel at 7 p.m. on Tuesday at Harry W. Schwartz Bookshop, 4093 N. Oakland Ave., Shorewood.



Arkady Renko on the case in 'Havana Bay'

Havana Bay. *By Martin Cruz Smith. Random House. 329 pages. $25.95*

By Dorman T. Shindler
Special to the Journal Sentinel

The gift that sets Martin Cruz Smith apart from other writers of mystery and suspense is his ability to guide readers into worlds and cultures that may have been heretofore unknown to them: from gypsies ("Gypsy in Amber") to North American Indians ("Nightwing," "Stallion Gate"), to 19th-century Welsh coal miners ("Rose") and preglasnost Russia ("Gorky Park").

With "Havana Bay," Smith visits modern-day Cuba and once again opens up a secretive, closed-door society. What's more, "Havana Bay" is his best Arkady Renko novel since "Gorky Park." High praise when you consider the quality of other books in the series ("Polar Star," "Red Square").

Still reeling from a personal tragedy, Detective Renko is sent to Cuba to identify the body of an accident victim — a Russian diplomat. The catch is that the victim is one Sergei Pribluda, one-time nemesis and, later, begrudging friend of Renko's.

From the opening chapter, Smith proves himself still capable of catching the reader off guard. He describes a scene in which the body (having floated in the sea for days) literally falls apart when being recovered. Such gruesome scenes are balanced by Smith's meticulous research into Cuban forensics and foreign police procedures, not to mention his love of language.

Smith describes Renko's first impression of Detective Ofelia Osorio, a woman who will become his only ally: "Her features were delicate and sharply cut, dark eyes made darker with suspicion as if she were an apprentice devil handed a tricky soul."

From the start, Renko senses something amiss with the death of his friend. But the Cuban police, especially Sergeant Luna, want Renko to identify the body and take it back to Russia on the first available flight. When Renko stalls, he finds himself a target for murder.

His efforts to investigate are hampered by a suspicious government — in Cuba, Renko discovers, Russians are as hated as Americans — and a rogue group of police led by the murderous Luna. Turning to Osorio for help, Renko uncovers a plot that seems to be leading to an assassination.

As revealed by Smith, modern-day Cuba is "the first place where time does not exist." Cars, clothes, music, even the people, seem to be trapped in a bygone era. Communism exists comfortably alongside exotic religions like Santeria. And Renko's de facto partner, Osorio, proves to be every bit as interesting, resourceful and enigmatic as Arkady.

The two detectives make perfect foils. Arkady's stoic and reserved manner is juxtaposed nicely with Ofelia's passionate, quick-tempered personality.

The desire for justice and insatiable curiosity are the common threads that bind them.

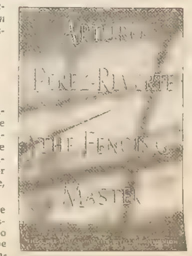
Like Walter Mosley, Martin Cruz Smith writes novels which transcend their given genre while evoking a particular time and place with unerring precision. Filled with Smith's trademark twists of plot and eye-opening revelations about Cuba, "Havana Bay" is a first-rate thriller.

Dorman T. Shindler is a freelance writer from Missouri.

Honor, intrigue sharpen intellectual thriller

The Fencing Master. *By Arturo Perez-Reverte. Translated from the Spanish by Margaret Jull Costa. Harcourt Brace. 244 pages. $24*

By David Walton
Special to the Journal Sentinel



The scene is Madrid, the summer of 1868. Rumors circulate the capital of an impending insurrection that will topple Queen Isabelle II, whose scandals have become too much for the politicians, if not the people, to bear.

Don Jaime Astarloa, the title character of "The Fencing Master," the fourth of Spain's Arturo Perez-Reverte's novels to be translated into English, is Madrid's greatest fencing master, a gentleman of the old school who, now in his 50s and white-haired, earns a threadbare living giving lessons to sons of the nobility. In this age of the pistol, Don Jaime is a throwback, a man of honor who has devoted his life to discovering the perfect fencing move: the "unstoppable thrust."

Perez-Reverte, the author of "The Flanders Panel," "The Club Dumas," and "The Seville Communion," is a former TV journalist who is now published in 30 countries in 19 different languages and has become one of the world's most popular novelists.

Often compared to Umberto Eco, Perez-Reverte writes what can be called intellectual thrillers — a kind of suspense novel that's founded upon a concept of art, philosophy, or in this case, fencing, and resolved along the logic of that concept. Meticulously researched, his novels are polished, erudite, cosmopolitan, but never plodding or stodgy. Certainly in the case of "The Fencing Master," never plodding.

Don Jaime receives an invitation to call upon a woman he assumes will be the mother of a prospective student — Dona Adela de Oreto, who instead proves to be a beautiful young woman with a tiny scar at the corner of her mouth and an unusual request. Dona de Oreto offers to pay Don Jaime twice his normal fee to teach her a secret thrust he is reputed to know, said to be impossible to parry.

At first Don Jaime refuses to accept a woman as his student. But Adela de Oreto proves persistent, and surprisingly knowledgeable about fencing, and eventually Don Jaime consents. He finds her a skilled fencer, fearless and determined. And soon, she's begun to awaken other feelings in him — feelings the aging Don Jaime hasn't felt for a woman in many years.

From this beginning, there evolves an intricate plot of moves and countermoves similar to the pattern of a fencing match, a tangled pattern of high politics and low betrayals that eventually, as the reader knows all along that it must, draws Don Jaime away from dusty treatises and arcane debates on the art of fencing and onto the floor of battle.

This is becoming quite a spring for Perez-Reverte, with a tour of eight American cities scheduled for June, the paperback release of "The Seville Communion," the release of "The Ninth Gate" and the film version of "The Club Dumas" directed by Roman Polanski and starring Johnny Depp as the rare book sleuth Lucas Corso.

Meticulously researched, Perez-Reverte's novels are polished, erudite, cosmopolitan, but never plodding or stodgy

David Walton, who lives in Pittsburgh, teaches writing and literature.

Frenetic satire on today's urban life at heart of long and winding 'Century'

By Anne Stephenson
Arizona Republic

Turn of the Century. *By Kurt Andersen. Random House. 659 pages. $24.95.*

You're going to read lots of reviews of this book, an inordinate number given that it's a 659-page first novel. Kurt Andersen is, as they say, connected, and at the other end of the tether are people any first novelist would love to know.

He is, at present, a columnist for The New Yorker.

In previous incarnations, he was co-founder and editor of Spy magazine, editor in chief of New York magazine and a producer of network television shows.

Before that, he had the foresight to work for several years on the staff of Time magazine, where his book has already received a full-page spread (Annie Proulx and Peter Matthiessen took what was left).

Does the book work for its living?

As a novel, no. As a manic satire on urban life as we know it (or will know it next year, which is when Andersen's story begins), yes, sort of.

At the center of its story are George Mactier and Lizzie Zimbalist, who have been married 10 years and have three kids, a Land Cruiser, dueling cell phones and a life that is blurry in its pace and trend-hopping zeal. George is a former journalist who now produces a television show called "NARCS," a drama that dabbles in "real" life (it is, George thinks, "extremely cool television"). Lizzie is a software entrepreneur.

The plot is not easy to describe, but that's not the novel's strong point anyway. What carries you along — and it's best to take it in doses, to avoid overkill — is Andersen's frenetic talent for skewering the shallow accoutrements of George and Lizzie's professional and personal lives, thereby reminding us of the deeper pleasures that have escaped them.

He does this so very well. He could have done it even better in a shorter book.

Shadows, Fire, Snow: The Life of Tina Modotti. *By Patricia Albers. Potter. 304 pages. $30*

She is known more for Edward Weston's photographs of her than for all of the photographs she made herself. After she died alone in a taxi cab at age 45, her death certificate listed her as a "housewife."

Yet Tina Modotti was a remarkable woman — independent, impassioned both politically and artistically, and surrounded by controversy.

In addition to Weston, (she became his model and then his lover, her desire "fueled by the authority of his creative accomplishment"), she knew some of the most interesting people of her time, including Pablo Neruda (the title of this book is from his poem, "Tina Modotti is Dead") John Dos Passos, Diego Rivera and Frida Kahlo.

Tina Modotti was a remarkable woman — independent and impassioned and surrounded by controversy

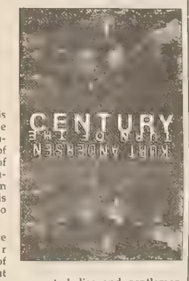
There have been other biographies of Modotti, but this is the best. Patricia Albers had access to two trunkloads of material from the estate of Modotti's first "husband" — they posed as a married couple but were not — that included three dozen letters written by Modotti and 100 images made by her.

"In portraying her," Albers writes, "my endeavor has been to keep one hand upon the tattered objects in the trunks."

The result is a portrait of an enigmatic woman who has been called the best "unknown" photographer of this century.

Working at Play: A History of Vacations in the United States. *By Cindy S. Aron. Oxford. 261 pages. $35*

At early 19th century resorts, men were permitted to gamble only if there were no women present, ladies and gentlemen swam in mineral springs at separate times, and everyone behaved impeccably. Back then, vacationing was the custom of an elite class looking for improved health. By World War II, it was a mass phenomenon.



Cindy Aron traces this evolution, and looks at the struggle with which Americans face their vacations today (it's a love/hate thing — we want to take vacations but fear the consequences).

More than just yearly rituals in which we connect with friends and family, vacations are exercises in self-definition," she writes. "In affording time away from the demands of everyday life, vacations disclose what people choose to do rather than are required to do."

This is as scholarly as a book about vacations can be, and well-planned — it's that time of year again

Liberal ideas take precedence in too-narrow Reuss 'memoir'

When Government Was Good. Memories of a Life in Politics. *By Henry S. Reuss. The University of Wisconsin Press. 177 pages. $22.95.*

By Frank A. Aukofer
of the Journal Sentinel staff

This small volume is billed as a memoir, but it could easily be retitled "The Essential Guide to the Fertile Liberal Mind of Henry S. Reuss."

Though it contains some autobiographical reminiscences, this is Reuss at his most insistent. At the age of 87, when most men would be kicked back somewhere cozy, the former Milwaukee congressman is still promoting ideas, trying to change minds and seeking to influence events.

Reuss

He lives now in San Francisco, but is essentially a German-American Milwaukeean of the old school of liberals and Socialists who espoused a clean and caring government that, at bottom, was dedicated to taking care of people.

Though Reuss had a patrician streak, and was comfortable in his long association with international bankers in dark pinstripes, he was equally at home in a seersucker suit and straw hat at a Fourth of July bull buggy parade in Gordon Park.

A Democrat, Reuss represented the 5th Congressional District for 28 years. Though a man of means, he was what one might describe as a "good liberal," with a populist streak dedicated to civil rights, environmental protection, cities, the outdoors, monetary and campaign finance reform and a brand of economics skewed toward ordinary folks and away from the rich and powerful.

He criticizes the home mortgage-interest tax deduction and the increase in the estate tax deduction as promoters of inequality. The former, he says, misallocates investment, steering it toward private mansions and away from productive plants and equipment.

Of the latter deduction, he argues that progressive income and estate taxes are the two great equalizers of the federal system. "We should be simplifying them and plugging loopholes, not systematically weakening them and thus creating greater inequality," he says.

Reuss describes "when government was good" as the two decades between 1948 and 1968. Interestingly, the latter date coincides with the first inaugural of President Richard M. Nixon. But many of the events he cites happened after 1968, including his own rise to influence as chairman of the congressional Joint Economic Committee and the House Banking Committee.

To win the latter job in 1975, Reuss toppled Texas populist Wright Patman in the caucus of House Democrats, effectively ending the long tradition of selecting chairmen strictly on seniority.

In his congressional career, Reuss promoted everything from getting the U.S. off the gold standard to the development of the Ice Age Hiking trail through Wisconsin. He loved the outdoors and could out-hike many men half his age.

Always there have been the ideas: Merging the city and county governments of Milwaukee for efficiency; passage of a constitutional amendment to provide for special presidential and congressional elections in times of crisis like those of the Nixon and Clinton presidencies; and creative ways to use old laws for new purposes.

Given the subject, this book is disappointingly thin. In choosing, as always, to give prominence to ideas, Reuss tells us too little about himself.

Frank Aukofer is the Washington, D.C., bureau chief for the Journal Sentinel.

Author Henry S. Reuss will sign copies of his book after a 7 p.m. talk on June 22 at Harry W. Schwartz bookshop, 4093 Oakland Ave., Shorewood.

Bader/There's no quit in art collector

I had gone into the station to get a map of (the city) and left Isabel with the luggage," Bader recalled

"While I was gone, a swarthy, bearded fellow came up and asked a question about a tram to distract her Before Isabel realized it, a woman had stolen my briefcase. It contained money, checkbooks, papers, lots of photographs — and the three small paintings.'

Stunned by their loss, the Baders rushed to the police in nearby Voorburgwal. Here, M Te Pas, "a very pleasant officer told them: "You'll never get the money back, but you may get the paintings back

Hoping Te Pas was right, Bader made two calls — one to a friend in London, about the missing checks; the other to an art dealer friend in The Hague, who told him: "Keep calm, we'll see '

He did just that

It was a dank, drizzly evening and their predicament did not cheer them as they waited glumly for news in their hotel room. No traveler's checks, no papers, no photographs, no paintings. Not even Alfred's list of telephone numbers for Dutch museums and other agencies that might help them

A True Boy Scout

Elsewhere in Amsterdam, however, a minor miracle was unfolding

At about 11 that night, miles from the train station, a Boy Scout leader named Bert Vos was walking home. In the moisture and murk, he spotted what appeared to be a pile of papers and photographs lying between two rubbish bins. Something told him it was not stuff somebody would toss away. He picked up the damp pile and took it to his modest apartment

Yes, it was the bulk of the materials from Alfred Bader's briefcase. And yes, too, the cash and traveler's checks were gone. But something more important was still there: a series of telephone numbers — for the Rijksmuseum (to which Bader had earlier sold a Rembrandt); for a Dutch art dealer in The Hague for Bader's son in Milwaukee

Vos didn't wait long to start calling

At the Rijksmuseum, he reached a guard who told him to call back in the morning. But the art dealer whom he contacted next, was within reach of the phone. Apprised of the situation, she urged Vos not to put the papers on the radiator

This advice proved invaluable, for lurking among the letters and photographs was a small but precious painting: the oil-on-panel "Portrait of a Man"

The painting, as Bader was soon to inform Vos, was almost certainly the best of the three works that had been in the briefcase. It had once belonged to the Hermitage Museum in St Petersburg, Russia, which had sold the work in 1935. The thief apparently had missed it because it was mixed in with the photos

(The portrait was thought at one time to be the work of Rembrandt himself. Bader now believes it is the creation of a "very good" Rembrandt student.)

"The thief didn't realize it was a painting," said Bader, who was alerted to the discovery by the art dealer. "It was in a glassine folder, hidden among about 50 photographs. 'Rembrandt's Mother' was more obvious. And the Coques painting, which had been attributed to Van Dyck, was in a fancy carved frame. The miracle is that Vos found the painting . . ."

Alas, both "Rembrandt's Mother," which Bader believes is the work of a Rembrandt student of 1630, and the elaborately framed sketch of a man, which he credits to Gonzales Coques, were still missing.

Bader's response was swift and decisive. He touched every base possible in his quest to get the works back

As any good collector of Dutch and Flemish Old Masters would do, he made sure that Interpol, the international police agency responsible for tracing stolen artworks, was notified. Too, he touched down with relevant museums, dealers and Rembrandt study groups Should the missing pictures ever come to market, they would be spotted almost immediately

Bader also offered Vos a reward for finding the painting — which the scoutmaster promptly turned down. In the end, Vos did let Bader to make a contribution to his scout troop. Impressed, the Baders invited Vos to visit them in Milwaukee — an invitation Vos was to accept several months later. A long-term friendship has grown out of that experience.

As for the two missing pictures — silence.

No sightings. No mysterious messages. No efforts to sell or to extort money

In the Lost-and-Found

Years passed

Finally, last December, Bader received a two-page fax from the director of the RKD, which keeps tabs on missing Old Masters. The fax informed him that an M.B.H. Schilder, a socio-ecologist who teaches at the University of Utrecht, had come by to ask about a painting, and they had had to tell him that it had been stolen — from Bader

It turned out that the two artworks had been recovered from a suspected drug dealer of Moroccan descent and placed by Dutch police in their lost-and-found department. There the pictures remained for the required three years, after which they were consigned to an auction house. The Baders were never notified.

Rudi Ekkart, director of the Institute for Art History, noted in a fax, dated Dec. 23, 1998, that according to the Dutch civil code, a work of art that has been bought in good faith longer than three years after the theft is the legal possession of the buyer Thus, the RKD could do little more than suggest that Bader negotiate with Schilder directly

Bader was now aware that both of his paintings had been sold at auction: "Rembrandt's Mother" to Schilder, the sketch of a man to a still-unknown purchaser. Only by accident had he learned the identity of the first buyer. He also was informed that the Dutch police had asked the auction house not to give Bader the name of the new owner of the second piece

"It never occurred to me to go to 'lost and found,' " Bader said, 'because I had given a two-page report to the police. All details were put in it."

Bader said he is particularly distressed because the Dutch police apparently never checked their own files before sending the stolen works to be sold at auction.

But the story doesn't end there.

Bader, ever the determined acquisitor, set out to recover what he saw as his property According to Dutch law, Schilder was now the legal owner of "Rembrandt's Mother." A sometimes tense exchange of letters followed, with Schilder holding out for a price Bader saw as unfairly high. Finally, a sum was mutually agreed upon.

"Rembrandt's Mother" is currently in the hands of the RKD, which will forward it to Bader when he visits England in July.

Bader has now set his sights on the Amsterdam police, who, he says, are preventing the auction house from giving him the name of the purchaser of the second stolen work, Coques' sketch of a man. Bader recognizes the buyer's title to the painting, but he is anxious to recover it.

"My argument," he stressed, "is with the Dutch police, not with the present owner . . ."

Bader said he is particularly incensed because he wrote to the Dutch police in February by certified mail and received no response.

In his letter, Bader asked the police to tell him who bought the second painting, and the price paid for it. Those questions remain unanswered.

Willem Russell, a specialist in art law, has already tried to convince the police to re-acquire the picture for Bader, "but in vain," Bader said. The intrepid art collector has also gained the ear of the U.S. ambassador to the Netherlands, Cynthia P. Schneider, who happens to be an art historian. Schneider has assured Bader she will do what she can for him.

And so it stands. For the moment

The missing sketch will be difficult to sell because it can never be shown outside Holland, for fear it will be seized, Bader said. Under U.S. law, the time limit for recovering stolen property is 40 years, as opposed to Holland's three. If the pilfered work is brought into the United States within the legal time limit, for sale or exhibit, Bader can reclaim it.

In the meantime, Bader persists in his efforts to re-acquire the diminutive but affecting "Portrait of a Man." If he succeeds, the 364-year-old portrait, handsomely mounted in its elaborately carved gilt frame, may one day materialize on a wall of his tiny Milwaukee gallery. But that is by no means certain.

What is clear is that Alfred Bader, a survivor of many kinds of war — military, political, industrial and artistic — has no intention of giving up.

Not now. Not ever

A detail of the once-stolen 17th-century portrait of Rembrandt's mother that is now in the hands of the Netherlands Institute for Art History. The institute is to return the work to Alfred Bader this summer.

Romance takes centre stage at Victoria University

Alfred Bader lost the love of his life and found her again 25 years later. Now he's given $6-million to build a theatre in her name

Alfred and Isabel Bader at Victoria University: a new theatre to mark a happy ending to a star-crossed romance JOHN MORSTAD/The Globe and Mail

LEE PARPART
Special to The Globe and Mail, Toronto

William Randolph Hearst built La Casa Grande at the height of his 30-year affair with Marion Davies. Mark Antony handed over large portions of Syria and Lebanon to Cleopatra. On a slightly different scale, Milwaukee philanthropist Alfred Bader is building a theatre in honour of his wife Isabel.

The retired chemical supplier, who now buys and sells Old Master paintings, recently donated $6-million to the University of Toronto's Victoria University to build a new, 500-seat venue to be called the Isabel Bader Theatre. Born in Kirkland Lake, Ont., Isabel Overton Bader graduated from Victoria in 1949 before going on to teach, design costumes and run a theatre group in England for 25 years. "I like Victoria college very much," Alfred Bader, 75, said, "but I would never have given this money if not for Isabel."

Construction on the theatre got under way in late July on a quiet stretch of Charles Street, in the heart of Victoria's downtown Toronto campus. The building is expected to open as a combined lecture hall and performance space in the fall of 2000. The gift is Victoria University's single largest in a long history of hefty donations by alumni and supporters, including the Massey family, Northrop Frye and the mother of former Ontario lieutenant-governor Hal Jackman.

Bader, who founded Aldrich Chemicals in a Milwaukee garage in 1951 and saw it grow into a $500-million-a-year business by the early 1990s, is already well known as a generous benefactor to his alma mater, Queen's University. He has donated more than $20-million in cash and kind to the Kingston, Ont., university over the years, showering it with Old Master paintings, scholarships and even a 15th-century English castle, Herstmonçeux, once owned by the ancestors of Hollywood star Ralph Fiennes.

Victoria University president Roseann Runte, who is editing a book of the couple's letters, to be published by the University of Toronto Press, said she views the theatre as a remarkable expression of a husband's love for his wife. "When he gave us the money for the theatre, it was because he wanted to make a gift to her. It's a kind of a double generosity, and a true love story."

The details of that story — a chance meeting on a ship to Europe in 1949, a quick marriage proposal, a separation of 25 years and a reunion in the mid-1970s — are described in Bader's 1995 autobiography, *Adventures of a Chemist Collector*, which also chronicles his life as an Austrian refugee.

Bader, a Jew, escaped to Britain as a teenager with the first *Kindertransport* group from Vienna in 1938, the British effort to rescue children from Hitler's European expansion. But he was later shipped to Canada when the British government developed cold feet about harbouring possible fifth columnists among its refugee population. Bader, two weeks past his 16th birthday, was reclassified as a prisoner of war, along with hundreds of other male refugees aged 16 to 65. He was sent to Canada in July of 1940, and spent 16 months interned in a camp on Ile aux Noix just off Montreal.

When he was released in 1941, Bader began applying to Canadian universities. Queen's University accepted him and Bader graduated with a degree in chemistry in 1945, a master's degree in 1947, and eventually received his PhD in organic chemistry from Harvard University in 1950.

It was on a break during his doctorate that Bader first encountered 22-year-old Isabel Overton in 1949. The two were on a ship bound for England; Bader was seeking relatives who might have survived the war, Isabel, a new Victoria graduate, was looking for a teaching post in England.

Bader proposed after only nine days, but Isabel hesitated. They travelled together briefly that summer and Isabel wrote 82 letters to Bader after accepting a teaching job in Sussex. But religious differences finally pulled them apart. Bader had stressed how much he wanted a Jewish family, and Isabel, a strong Protestant at the time, was not ready to convert. "I was not absolutely against the idea," she recalled recently. "But it wasn't something I could do in a hurry." (She later converted to Judaism in 1991, nine years after the couple were married in a civil ceremony.)

After Isabel turned down his proposal, Bader returned to Milwaukee, started a business and, eventually, married a Jewish woman, with whom he had two sons. But Bader says he never forgot Isabel. His book says he imagined her "happily married to a WASP . . . with six children, occasionally laughing at the fool Jew who had fallen so head over heels in love with her." And he admits to "masochistically" rereading her letters to him every year on her birthday.

In 1975, when Bader tried to track Isabel down, he was amazed to find her still teaching at the Bexhill Grammar School in Sussex where he had left her in 1949. She had stayed there, hoping he would come back, but when he did, it was traumatic. In 1981, after many tearful rejections ("She kept saying, 'You're married, go away,'" Bader recalled) and, finally, an uncontested divorce from Bader's first wife, Alfred and Isabel started their life together.

Since marrying in 1982, the two have been inseparable. While Bader was still working for Sigma-Aldrich (his company had merged with another chemical supplier in 1975), Isabel joined him on trips to labs and universities around the world. When Bader was voted off the company board in 1992 for an alleged financial indiscretion, the couple switched gears.

Bader, who had been running a small art dealership on the side since 1961, stepped up his activities and moved Alfred Bader Fine Arts into a small space in Milwaukee's historic Astor Hotel. On his first foray into high-stakes dealing, he sold a Rembrandt portrait to the Rijksmuseum in Amsterdam for $10-million (U.S.); the business now handles roughly 200 paintings a year.

The Baders have become an unlikely fixture on the British and New York auction scenes — down-to-earth multimillionaires who prefer public transit while travelling, shun vacations ("Cape Cod is for rich people," Bader smiles) and dress in department-store chic.

But if their fashion sense is [illegible] last year at Sotheby's in New York, they bought Rembrandt's 1633 *Portrait of a Bearded Man in a Red Coat* for $9-million (U.S.) and Rubens's c.1609 work, *The Head of St. John the Baptist Presented to Salome*, for $5-million (U.S.). Both paintings have since been sold to Las Vegas casino director Steven Wynn, for what Bader described as a "comfortable profit."

While he treats the multimillion dollar art purchases as "selling potatoes," Bader is also an avid collector. He thrives on the hunt and loves finding dirty, damaged and moderately priced work lying around in antique shops. He has discovered more than one diamond in the rough, including a valuable 1646 still life by Pieter Claesz that he purchased for a mere $250.

Every dollar he saves by chasing down bargains, however, is another 50 cents the couple chooses to give away. Some of the couple's income goes toward left-leaning international causes, such as Middle East peace initiatives and financial support for the former Czechoslovakia's Roma population. Smaller amounts go to keeping up the Baders' memberships in the American Civil Liberties Union and the National Association for the Advancement of Coloured People. The rest goes to universities.

And for that, Victoria president Runte is grateful. While the college has no drama school that would require it to own a theatre, it hosts what Runte calls "the oldest living dramatic revue in North America," an annual comedy show called *The Bob*. And along with its strong tradition of literary criticism (Northrop Frye studied and later taught at Vic and Margaret Atwood is a graduate), the school has a history of fostering dramatic talent. "We have a number of distinguished directors and actors, including Norman Jewison and Donald Sutherland as graduates, and they've never had a stage to practise on," said Runte.

The theatre is being designed by Toronto architect Peter Smith, who has drawn plans for 40 other performing-arts facilities, including Toronto's Princess of Wales Theatre. Smith described the Vic project as an "intimate" two-level theatre; it will have basic staging and audio-visual equipment in the first year, with room to grow in future years.

As for any future philanthropic gestures, Bader admits to not liking being solicited for money. But husband and wife insist that giving it away is one of their prime pleasures in life.

"We can't take it with us," Bader is fond of saying, "so why shouldn't we have fun while we're alive."

"We could spend it on riotous living, which many people do," Isabel adds, "but neither one of us likes to live riotously. Or at least, our type of riotousness is rather different."

How Amanda got her groovy cello back

FORSYTH SAGA

Someone stole Amanda Forsyth's cello. But the incident was just a temporary setback in the rapid rise of the National Arts Centre Orchestra's principal cellist

PHILIP ANSON
Special to The Globe and Mail, Ottawa

It was a terrible way for Amanda Forsyth to mark the end of her first year as principal cellist of Ottawa's National Arts Centre Orchestra. A week before the last concert of the season, a thief walked out of the NAC with her $30,000 cello.

"I went to my locker in the morning and it was gone," the 33-year-old musician confided over coffee in Ottawa last weekend. "I felt like someone had taken my soul," she lamented, still smarting from the experience days after the instrument was recovered from a Gatineau-area home.

But she's bouncing back, thanks to protective friends like the young woman who accompanied her to the interview, and her little white lap dog: "Not a poodle, a Maltese with bad hair," she joked.

At first, Ottawa police suspected the thief was another fan obsessed with Forsyth, a striking blonde with perfect teeth and startling hazel eyes. It wouldn't be the first time. She once needed a bodyguard to protect her against a stalker. These days, her personal trainer, who formerly worked for the Ottawa Senators hockey team, remains on call to discourage unwanted admirers.

Ottawa police quickly decided the NAC thief was not a stalker. "This guy just wanted an instrument to play, and my red cello case probably caught his eye," Forsyth explained. The loss was particularly difficult for Forsyth since, unlike most musicians, she owns only one instrument.

The prized possession was a pale brown, lightly varnished cello made in 1981 by David Wiebe, who once made a viola for Yehudi Menuhin. Wiebe goes to the forest and taps trees and does the mythical thing of selecting his own tree," said Jack Lorius, who has done maintenance on Forsyth's cello. Insured for only $30,000, Forsyth's Wiebe is not in the same league as Stradivari, which sell for up to a million dollars. "It's probably the least valuable cello at the NAC," she admitted, "but we've been through a lot together."

Forsyth's rapid career rise has been a Canadian classical-music success story. The Forsyth family moved from Capetown, South Africa to Edmonton when Amanda was 2. Her father, award-winning composer Malcolm Forsyth, played trombone in the Edmonton Symphony and taught at the University of Alberta. Her mother Lesley was a former ballerina (the couple divorced in the late 1970s).

Amanda started playing at the age of 3 on a mini-cello (actually a viola with an end pin attached), progressing through increasingly larger cellos. As a teenager, she took lessons from the legendary William Pleeth in London, England, and played for Jacqueline Du Pré, the acclaimed cellist who was already dying of the multiple sclerosis that would claim her in 1987. "She was my idol," said Forsyth. "But that movie is terrible trash," she added, referring to *Hilary and Jackie*, the 1998 biopic that depicts Du Pré as a selfish nymphomaniac.

Forsyth spent her high school years in Vancouver before attending New York's prestigious Juilliard School. "At 16, I was ready for New York, but my parents were not," she noted wryly.

As soon as she turned 18, she was off to Manhattan, where she had "the best time." Since she graduated from Juilliard in 1989, Canadian orchestras have vied for her talents. She quickly moved from the Toronto Symphony to first cellist position with the Calgary Philharmonic in 1992. Since last year, she has been with the National Arts Centre Orchestra.

Her recording career has kept pace. A CBC recording called *Electra Rising*, which featured a concerto her father wrote for her, won a 1998 Juno Award. Another father-daughter disc called *Soaring with Agamemnon* on Marquis Classics was released earlier this year.

The disappearance of Forsyth's cello couldn't have come at a worse time: She had three Ottawa concerts and a recording session scheduled. She cancelled one concert but made the CBC Records recording on a borrowed instrument.

Meanwhile, her cello and its bright red case were spotted in the hands of a curly-headed Ottawa teenager at an Ottawa Chamber Music Festival rehearsal and at a jam session at the Celtic Cross pub on Bank Street.

Locals compared the cello's wandering to Francois Girard's movie *The Red Violin*, which follows a violin as it changes hands through the centuries. Finally, eight days after the instrument went missing, detectives tracked the cello to a Gatineau home, where the culprit's tearful mother turned it over to the authorities.

Forsyth rushed to the local police station, where she gave an impromptu recital to check for damage. "I had nightmares it had been sledgehammered, but it was basically okay," she recalled with relief.

The 17-year-old amateur musician, whose name is protected by the Young Offenders Act, is wanted for theft and possession of stolen property over $5,000. Police believe he has left Ottawa.

One unwelcome side effect of the recent cello theft is heightened curiosity about the musician's alleged personal relationship with the NAC's new music director, 51-year-old Israeli violinist Pinchas Zukerman. Zukerman is currently divorcing his second wife, actress Tuesday Weld.

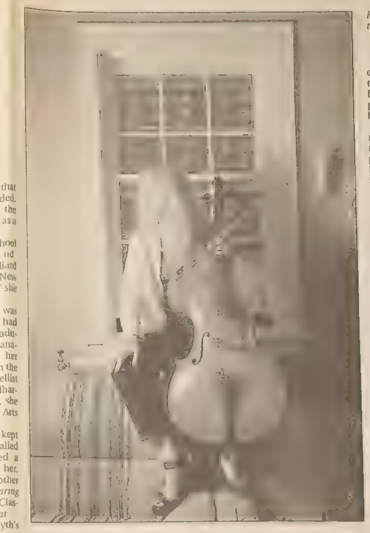
According to a media report, the rumoured liaison has Rockliffe society tongues wagging. Whether or not the rumours are true, Forsyth seems ready to put down roots in Ottawa, confirming that she has just sold her Calgary home.

The rumours have not hurt her career. She recently recorded Mozart's *Flute Quartets* with Zukerman, as well as the soundtrack for an upcoming Rhombus film of the ballet, *The Four Seasons*, both for CBC Records. And Forsyth will play Boccherini's *Cello Concerto* with the NAC next season, under Zukerman's direction.

In conversation, she refers frequently to "Pinchas" and is obviously supportive of his leadership. "I think the NAC is on the brink of a huge step up with Pinchas and the new bosses," she said, referring to NAC's incoming CEO, Peter Herrndorf, and new chairman of the board, David Leighton.

With her cello back, Forsyth's life is back on track. "All's well that ends well, I guess," she shrugged. Or almost. While trying out substitute cellos last week, she unexpectedly fell in love with another instrument.

"I was never tempted to be unfaithful to my Wiebe but now, I have to admit, I want a Strad!" she laughed. Unlikely — but, then again, who knows? A Strad for Christmas would be a fitting end to the Forsyth saga.

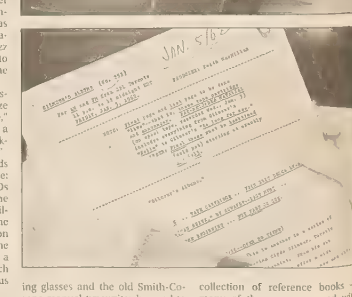


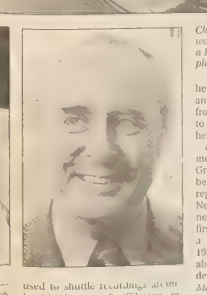
Forsyth and her cello: 'We've been through a lot together.'
DAVE CHAN/The Globe and Mail

RADIO REVISITED

Being at home with Clyde

The CBC has installed the home office of beloved broadcaster Clyde Gilmour in its music library.





Clockwise from above: Gilmour's work space; the broadcaster in 1979; a 1962 radio script; his rotary phone. JOHN MORSTAD/The Globe and Mail

COLIN EATOCK
Special to The Globe and Mail, Toronto

As Clyde Gilmour would have said at a moment like this, "Hullo."

Welcome to the Clyde Gilmour Corner, tucked away in the music library of the labyrinthine CBC building in Toronto.

Here you will find a sort of shrine to Gilmour and his *Gilmour's Albums* radio program that graced CBC Radio's airwaves for an astounding 41 years — the longest running recorded music radio program in Canadian history. Rather like Cézanne's studio in Aix-en-Provence, Gilmour's workspace has been preserved exactly as the famous classical-music and jazz broadcaster left it in his Toronto home when he died in 1997 at the age of 89.

"We've tried to capture the essence of the man, as well as utilize his collection for our advantage," said CBC archivist Pat Kellogg in a recent interview. "He was a packrat, but everything had a purpose."

Not surprisingly, the records themselves dominate the scene: 10,000 LP albums and 4,000 CDs stacked around the perimeter of the area, many of them still in Gilmour's original cabinets. In the midst of this impressive collection is Gilmour's old wooden desk, the top of which (now protected by a clear plastic casing) reveals much about the personable, fastidious and rather eccentric man.

"Proud old rotary phone, not a goddam push button," reads the red dymo-tape inscription that Gilmour affixed to his black telephone. (Gilmour seems to have had an obsession with dymo-tape: the adhesive plastic ribbon with embossed lettering is stuck on virtually everything he owned.)

As well, there are the stop watches he used to time his recordings for broadcast ("He had two, because he didn't trust any single one," Kellogg explained), his reading glasses and the old Smith-Corona manual typewriter he used to bang out his weekly radio shows. And taped to the desk is a 1955 photo of his wife, Barbara, who [illegible] Clyde with his massive correspondence.

Carefully preserved in filing cabinets is [illegible] *Gilmour's Albums* scripts, dating from his first broadcast on Oct. 5, 1956, to his last on June 11, 1997, as well as many of the record and film reviews he wrote for various publications. His extensive collection of reference books — many of them so crammed with clippings and articles that they won't close properly — is also part of the archive.

[illegible] collection's chief purpose is as a research tool for CBC staff and others, the thoroughness with which Gilmour's life has been recorded [illegible] an act of love. How else to explain the preservation of his record-cleaning machine or the replica of the supermarket shopping cart he used to shuttle recordings around in his basement? (Gilmour researched and prepared his shows at home, then would record the program in a CBC studio.)

[illegible] people love him. "He was conversational, easy to listen to and had a good clear use of language," recalled Gilmour's daughter, Jane Gilmour. "People liked it [illegible] because it wasn't all opera, or all jazz, or all Wayne and Shuster. He spoke into the microphone as if he were speaking to one person; and he imagined his ideal listener to be an intelligent 50-year-old woman from Alberta, who enjoyed listening to music she might not be able to hear where she lived."

A native of Alberta himself, Gilmour was born in Calgary in 1912. Growing up in Medicine Hat, he became a journalist at the age of 18, reporting for The Medicine Hat News. After writing for various newspapers in Western Canada, he first worked for the CBC in 1947 as a film reviewer in Vancouver. In 1954 he moved to Toronto, writing about music and film for the now-defunct *Toronto Telegram* and for *Maclean's* magazine. [illegible] later, he launched *Gilmour's Albums*, his one-hour weekly program that ran 52 weeks a year — with no reruns — for more than four decades.

Jane Gilmour recalls the home of her broadcaster father as somewhat out of the ordinary, by the standards of their west Toronto neighbourhood. "It was more like the Beaver Cleaver environment I grew up in to have a father who worked at home. He was downstairs most of the time, coming up for lunch, or to ask my mother's advice. He gradually took over the whole lower level of the house — even the laundry room was full of his records and players."

And now the CBC music library is full of his records and notes, thanks to Gilmour's daughter, who is responsible for transferring the collection to the CBC. (The CBC doesn't actually own it yet, but negotiations are in progress.)

While Gilmour fans will be heartened to know that his work has been so carefully preserved, they may be disappointed to discover that the Clyde Gilmour Corner is [illegible] exception is the open house that the CBC holds a couple of times a year, and Kellogg expects the collection to be a hit when the CBC building next opens its doors to visitors this year, [illegible] date has yet to be announced. "I'm sure people will be very interested. People want to connect with the man."

COLLECTOR'S CORNER CARRIES THE TORCH

Although James Manishen never met Clyde Gilmour, like many Canadians, he came to feel that he knew the Toronto broadcaster through his weekly program on CBC Radio. "All my life I was a fan of Gilmour's Albums; it was a fixture in my home," explained Manishen, now the host of Collector's Corner, a new CBC show produced in Winnipeg. "A great deal of my early taste came from that program."

Since last fall, the Winnipeg-born Manishen has been doing what the late Clyde Gilmour did for 41 years: assembling a weekly show based on his own eclectic collection of recordings.

"It's a rebirth only in format," said Manishen, comparing his show to *Gilmour's Albums*. "On the program I've had cowboy songs, world music, classical music, spoken word, everything. I try to bring a Canadian emphasis to what I do, and I have a great interest in historical recordings."

And, like Gilmour, Manishen has found that his program touches a wide variety of listeners. "Because the CBC can be heard anywhere on the Internet," he explained, "I get E-mail from all over the world. People write from all parts of Canada, the U.S., Europe, Israel and even Australia. It's a pleasure when people write to say I've opened a new door for them, by introducing them to something they hadn't heard before."

A former clarinetist with the Winnipeg Symphony Orchestra, Manishen became involved in broadcasting about three years ago. And at the age of 49, he feels he's found his calling. "I don't know if my show will run for 41 years, but I want to keep doing this for as long as I can."

Collector's Corner can be heard Saturdays at 12:30 p.m. (1:30 p.m. in the Maritimes and 2 p.m. in Newfoundland) on CBC's Radio Two network.

— Colin Eatock

How Amanda got her groovy cello back

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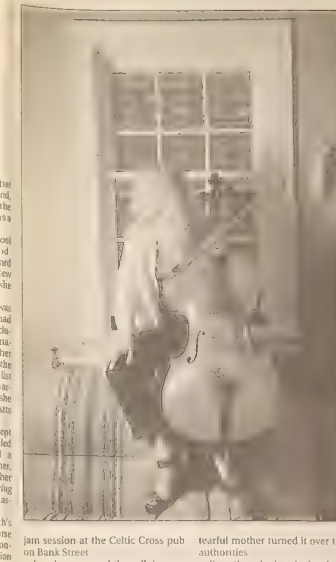
The rumours have not hurt her career. She recently recorded Mozart's *Flute Quartets* with Zukerman, as well as the soundtrack for an upcoming Rhombus film of the ballet, *The Four Seasons*, both for CBC Records. And Forsyth will play Boccherini's *Cello Concerto* with the NAC next season, under Zukerman's direction.

In conversation, she refers frequently to "Pinchas" and is obviously supportive of his leadership "I think the NAC is on the brink of a huge step up with Pinchas and the new bosses," she said, referring to NAC's incoming CEO, Peter Herrndorf, and new chairman of the board, David Leighton

With her cello back, Forsyth's life is back on track "All's well that ends well, I guess," she shrugged. Or almost. While trying out substitute cellos last week, she unexpectedly fell in love with another instrument

"I was never tempted to be unfaithful to my Wiebe but now, I have to admit, I want a Strad!" she laughed. Unlikely — but, then again, who knows? A Strad for Christmas would be a fitting end to the Forsyth saga

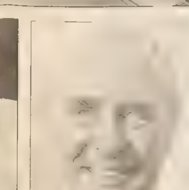


Forsyth and her cello: 'We've been through a lot together.' DAVE CHAN/The Globe and Mail

RADIO REVISITED

Being at home with Clyde

The CBC has installed the home office of beloved broadcaster Clyde Gilmour in its music library.



Clockwise from above, Gilmour's work space; the broadcaster in 1979 a 1962 radio script; his rotary phone. JOHN MORSTAD/The Globe and Mail

COLIN EATOCK
Special to The Globe and Mail, Toronto

As Clyde Gilmour would have said at a moment like this, "Hullo "

Welcome to the Clyde Gilmour Corner, tucked away in the music library of the labyrinthine CBC building in Toronto

Here you will find a sort of shrine to Gilmour and his *Gilmour's Albums* radio program that graced CBC Radio's airwaves for an astounding 41 years — the longest running recorded music radio program in Canadian history. Rather like Cézanne's studio in Aix-en-Provence, Gilmour's workspace has been preserved exactly as the famous classical-music and jazz broadcaster left it in his Toronto home when he died in 1997 at the age of 85

"We've tried to capture the essence of the man, as well as utilize his collection for our advantage,' said CBC archivist Pat Kellogg in a recent interview. "He was a pack-rat, but everything had a purpose."

Not surprisingly, the records themselves dominate the scene 10,000 LP albums and 4,000 CDs stacked around the perimeter of the area, many of them still in Gilmour's original cabinets. In the midst of this impressive collection is Gilmour's old wooden desk. the top of which (now protected by a clear plastic casing) reveals much about the personable, fastidious and rather eccentric man

"Proud old rotary phone, not a goddam push button," reads the red dymo-tape inscription that Gilmour affixed to his black telephone (Gilmour seems to have had an obsession with dymo-tape: the adhesive plastic ribbon with embossed lettering is stuck on virtually everything he owned.)

As well, there are the stop watches he used to time his recordings for broadcast ("He had two, because he didn't trust any single one," Kellogg explained), his reading glasses and the old Smith-Corona manual typewriter he used to bang out his weekly radio shows And taped to the desk is a 195 photo of his wife, Barbara, who — among other things — helped Clyde with his massive correspondence

Carefully preserved in filing cabinets are 2,083 *Gilmour's Albums* scripts, dating from his first show on Oct. 5, 1956, to his last on June 14, 1997, as well as many of the record and film reviews he wrote for various publications. His extensive collection of reference books — many of them so crammed with clippings and articles that they won't close properly — is also part of the archive

Despite Kellogg's claim that the collection's chief purpose is as 'a research tool for CBC staff and others, the thoroughness with which Gilmour's life has been reconstructed can only be described as an act of love How else to explain the 'preservation of his record-cleaning machine or the replica of the supermarket shopping cart he used to shuttle recordings around in his basement? (Gilmour researched and prepared his shows at home, then would record the program in a CBC studio)

But Gilmour had a way of making people love him "He was conversational, easy to listen to and had a good clear use of language," recalled Gilmour's daughter, Jane Gilmour. "People liked his show because it wasn't all opera, or all jazz, or all Wayne and Shuster. He spoke into the microphone as if he were speaking to one person; and he imagined his ideal listener to be an intelligent 50-year-old woman from Alberta, who enjoyed listening to music she might not be able to hear where she lived

A native of Alberta himself, Gilmour was born in Calgary in 1912 Growing up in Medicine Hat, he became a journalist at the age of 18 reporting for The Medicine Hat News. After writing for various newspapers in Western Canada, he first worked for the CBC in 1947 as a film reviewer in Vancouver In 1954 he moved to Toronto, writing about music and film for the now-defunct *Toronto Telegram* and for *Maclean's* magazine. Two years later, he launched *Gilmour's Albums*, his one-hour weekly program that ran 52 weeks a year with no reruns — for more than four decades

Jane Gilmour recalls the home of her broadcaster father as somewhat out of the ordinary, by the standards of their west Toronto neighbourhood. "It was unusual in the Beaver Cleaver environment I grew up in to have a father who worked at home. He was downstairs most of the time, coming up for lunch, or to ask my mother's advice. He gradually took over the whole lower level of the house — even the laundry room was full of his records and notes '

And now the CBC music library is full of his records and notes, thanks to Gilmour's daughter, who is responsible for transferring the collection to the CBC. (The CBC doesn't actually own it yet, but negotiations are in progress)

While Gilmour fans will be heartened to know that his work has been meticulously preserved, they may be disappointed to discover that the Clyde Gilmour Corner is closed to the general public. An exception is the open house that the CBC holds a couple of times a year, and Kellogg expects the collection to be a hit when the CBC building next opens its doors to visitors (the exact date has yet to be announced). "I'm sure people will be very interested. People want to connect with the man.'

COLLECTOR'S CORNER CARRIES THE TORCH

Although James Manishen never met Clyde Gilmour, like many Canadians, he came to feel that he knew the Toronto broadcaster through his weekly program on CBC Radio "All my life I was a fan of Gilmour's Albums, it was a fixture in my home," explained Manishen, now the host of Collector's Corner, a new CBC show produced in Winnipeg "A great deal of my early taste came from that program."

Since last fall, the Winnipeg-born Manishen has been doing what the late Clyde Gilmour did for 41 years assembling a weekly show based on his own eclectic collection of recordings

"It's a rebirth only in format," said Manishen, comparing his show to *Gilmour's Albums* "On the program I've had cowboy songs, world music, classical music, spoken word, everything I try to bring a Canadian emphasis to what I do, and I have a great interest in historical recordings "

And, like Gilmour, Manishen has found that his program touches a wide variety of listeners "Because the CBC can be heard anywhere on the Internet," he explained, "I get E-mail from all over the world People write from all parts of Canada, the U S., Europe, Israel and even Australia It's a pleasure when people write to say I've opened a new door for them, by introducing them to something they hadn't heard before."

A former clarinetist with the Winnipeg Symphony Orchestra, Manishen became involved in broadcasting about three years ago. And at the age of 49, he feels he's found his calling 'I don't know if my show will run for 41 years, but I want to keep doing this for as long as I can

Collector's Corner can be heard Saturdays at 12:30 p.m (1.30 p.m. in the Maritimes and 2 p.m in Newfoundland) on CBC's Radio Two network

Colin Eatock

Red Violin turns green in U.S.

The [illegible] the film by Quebec director [illegible]ois Girard, ha[s] pa[ssed the] [illegible] million mark (U.S.) in [illegible] box-office receipts [illegible] Pro[ducer] [illegible] predicts the $9[illegible] production will eventu[illegible] ally [illegible] $6-million, making it the [most] [s]uccessful Canadian film ever [illegible] United States. [illegible] Vancouver's Lion [illegible] [illegible] [illegible] several [illegible] fore[illegible] Spain and [illegible] open[illegible] next month.

ARTS INK

Last weekend, the film [illegible] $184,091 on 117 screens, bringing its total North American box-office revenue to $7,398,593. — *Staff*

Hitchcock's house gets plaque

Alfred Hitchcock's daughter unveiled a plaque in London yesterday to commemorate the 100th anniversary of the director's birth. The plaque honouring Hollywood king of suspense was put up at the West London house where he lived after his marriage until he moved to the United States in 1939.

"I am so grateful for having this wonderful ceremony for my father. It is an incredibly great honour," said his daughter Patricia, who occasionally appeared in her father's films. — *Reuters*

Lewis beats back meningitis

Veteran U.S. comedian Jerry Lewis said yesterday he was delighted to be alive after a bout of viral meningitis that forced him to cancel an Australian tour. "I didn't think I'd see anybody else again. I thought there was no way back," Lewis told reporters in Sydney before flying home to the United States.

Lewis, 73, who first became famous for his double act with the late Dean Martin, was admitted to a Darwin hospital last week after being diagnosed with the potentially fatal illness. Lewis, who was forced to cancel his shows in Adelaide and Sydney, said the health care had forced him to re-evaluate his lifestyle, adding he planned to eat less red meat and more vegetables.

However, the comedian had no plans to give up entertaining. "Give show business away? You might as well let me die now," Lewis said. "It was an incredible experience. I'm delighted to be here. I open my eyes this morning and I figure I'm a hit!" — *Reuters*

Fringe hit to be remounted

The Drowsy Chaperone, the musical hit of Toronto's recent fringe festival, will be remounted later this year at the 180-seat Artwood Theatre.

Mirvish Productions communications director John Karastamatis was so impressed by the show, written by Lisa Lambert and Greg Morrison, that he decided to make his producing debut with it. He says the show will open in late November for a four-week run.

The show, starring film veteran Don McKellar, is expected to be reworked in the intervening months to add a second act. — *Staff*

Swing revues invade theatres

Can swing music be a winner on stage? Two theatrical producers are betting it can. Taurpro Entertainment's Jeffrey Latimer is planning to mount *Forever Swing* (a musical-revue cousin of *Forever Plaid* and *Forever Tango*) at Toronto's Winter Garden Theatre in October.

At the same time, a British producer has booked the Apotex Theatre at the Ford Centre for the Performing Arts for *Swing Step*, a new musical with a book by Canadian actor-writer Ted Dykstra (*Two Pianos, Four Hands*).

The show, which has already had one tryout in Myrtle Beach, S.C., is also scheduled to open here in October. — *Staff*

Duchovny lawsuit is out there

David Duchovny, star of the hit TV series *The X-Files*, has sued Rupert Murdoch's Twentieth-Century Fox Film Corp., alleging that the studio cheated him out of millions of dollars in profits, Daily Variety reported yesterday.

The Hollywood trade paper quoted sources as saying Duchovny is seeking at least $25-million (U.S.) in damages, although the suit did not mention a sum. — *Reuters*

LIFE

LIFE LINE

tigating a possible link between stir-prisingly high rates of lung cancer ıen. Stir-frying has long been recom-ooking healthy, low-fat food. But sci-nd Hong Kong are now studying the ewer than one in 25 women smoke in en are among the heaviest smokers in the world. Yet Chinese men are only about three times more likely to contract lung cancer than women. In the West, the lung cancer ratio is four men to every woman. Dr. Wendy Hsiao, a cancer biologist at the Hong Kong University of Science and Technology, said fatty cooking fumes had long been ignored as a possible cause of cancer. She has taken samples in Hong Kong's back alleys, where restaurants fumes. "Since there is such a high concentra investigating the pollutants in the outside ai are relatively low in modern kitchens, which f els. "For people to contract cancer usually tak we are detecting now reflects the situation 20 tion in kitchens was not so good." *David Renn*

He never forgot her: Alfred and Isabel Bader at the dedication ceremony for the Isabel Bader Theatre at Toronto's Victoria University.

Isabel Overton met Alfred Bader just after the Second World War. Religious differences kept them apart for decades. Love brought them together at last

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Isabel Overton met Alfred Bader just after the Second World War. Religious differences kept them apart for decades. Love brought them together at last

Dear Alfred: The letters he cherished

By Rondi Adamson

'I feel that I've come home," wrote Alfred Bader in 1977 when he saw his old flame, Isabel Overton, after a 26-year separation. The two had first met in 1949, when Isabel, then in her early 20s, boarded the SS Franconia headed for Europe from Quebec. Overton had recently graduated from Victoria University in Toronto, and had convinced her parents to let her go with a girlfriend on a bicycle tour of England. This was unusual for the time, but then Overton had been pretty determined from childhood on. She grew up in Kirkland Lake, Ont., and — also unusual for the 1940s — was not only intent on going to university, but on doing so in Toronto.

On board the Franconia, Overton met Bader, who was her senior by a couple of years. He had come to Canada via England several years earlier as a refugee from *Anschluss*-era Austria. He was travelling to England to visit the family that had taken him in when he first left Austria.

Unembarrassedly, he remembers his first meeting with Overton as nearly love at first sight. Nine days later he proposed marriage. (He now says he wonders what took him so long.) She said no, but not because she didn't love him. Bader was Jewish, and she didn't feel she could convert, though they remained friends and saw each other in England as much as possible.

"Wartime price controls were still in effect," he remembers, "so I could afford to ask her out to dinner." For the next two years, they stayed in touch, mostly via letters. Bader even met Overton's family when he returned to North America.

Bader hoped Overton would change her mind but decided he had to settle his own life. He assumed that Overton must have another man in her life — because, he thought, she was so beautiful, how could she not? — and wrote less and less. Finally, in 1951, the letters stopped from both sides.

Bader moved on, founding Sigma-Aldrich, a chemical company in the States. He married, had a family and achieved huge financial success. (He has an extensive art collection of 16th- and 17th-century masters.) But hardly a day went by, he says, without a thought to Overton and all the what-might-have-beens. She, in the meantime, stayed in England where she taught at a girls' school and founded the Bexhill Costume Museum. She did not marry.

The young Isabel Overton

In 1975, Bader had a dream in which Overton's father appeared to him, chastising him and saying "How can you leave my daughter alone?" The week of the dream, Overton's father, then 93, passed away. Though still married, Bader set out to find Overton, contacting many of her friends, including one in Japan, trying to get her address. When he did, he wrote to her, asking if they could meet. Perhaps not surprisingly, she said no, knowing he was married and wanting to leave the past in its place. But after so many years, and after the dream, Bader would not be deterred. He kept up his lobby until 1977, when Overton capitulated.

Patience was a virtue both Bader and Overton needed to invest in, as it would be another four years before he divorced. Bader and Overton married in the early 1980s and she converted to Judaism. They have been together — blissfully — since. "They are the type of people," says friend Roseann Runte, the president of Victoria University, "who hold hands all the time. They act like a young couple who just met." They also, says Runte, firmly believe that Overton's father appeared to Bader in an attempt to help his daughter get her ducks in a row before he died.

Still, Bader, never one for small gestures (this is the man who donated Herstmonceux Castle to his alma mater, Queen's University) felt that their being together was not enough in itself. Wanting to do something out of the ordinary for his wife, he took her letters from 1949-1951 (his letters from that time were lost) and approached Runte, whom they knew from Isabel's involvement with Victoria University. "He asked me if I thought they would be of interest to anyone but himself." Runte did and helped Bader find a publisher.

The result is *A Canadian in Love* (University of Toronto Press, $36) on sale today at the Victoria University bookstore and, starting tomorrow, at most other bookstores. The book — edited and with an introduction by Runte — is being released in a limited edition of 1,000 copies. "Alfred wanted this to be special for Isabel, not something we'll see on airport bookstore racks in paperback in three years," says Runte. Proceeds from the book, in a nod to Isabel's devotion to Victoria University, will go to a scholarship fund named for Ann Lewis — Runte's secretary, who typed up the original manuscript. (In case this weren't a big enough valentine, Bader has recently donated $6-million to the school for a theatre to be built in Isabel Bader's name.)

The book contains over 80 letters written by Overton to Bader. Runte believes the book will appeal to more than the romantics out there.

"Yes, it speaks to that belief we all want to have, that there is someone out there for each of us. But it also contains fascinating observations of postwar England; of the differences between Canada and England; of a Canadian woman's simultaneous homesickness and thrill at being in a new culture, exposed to great theatre, art and architecture."

There are two letters in the book not written by Overton. One is from her mother to Bader, written in 1951, telling him she knows her daughter loves and misses him and that she believes their religious differences can be overcome. The other is from Bader to Overton, written after their 1977 reunion, the letter in which he tells her he feels he has come home. It is the final letter in the book.

National Post

Rekordpreise in London: Die Rothschild-Aktion brachte 1,2 Milliarden Schilling

Schweres Los, glückliches Ende

Die Versteigerung der österreichischen Rothschild-Pretiosen am Donnerstag in London geriet zur größten Auktion einer privaten Sammlung in Europa: Der Gesamterlös übertraf die kühnsten Erwartungen – und lag dreimal so hoch wie der Schätzpreis mit 420 Millionen Schilling. Österreichische Museen konnten kein einziges Stück zurückerwerben.

London/Wien – Donnerstag spätabends, nach der Auktion, sprach ein enthusiastischer Lord Hindlip, Vorsitzender von *Christie's International* und in Österreich durch die *Mauerbach-Auktion* bekannt, seinen Dank an Bettina Looram-Rothschild, die Vertreterin der Erben, aus: Die Auktion brachte einen Gesamterlös von umgerechnet mehr als 1,2 Milliarden Schilling und wurde damit der größte *Single Owner Sale* in Europa.

Das überragende Ergebnis zeichnete sich bereits zu Beginn der *Evening Session* ab, als das *Rothschild-Gebetbuch* für 180,4 Millionen Schilling und das *Cornaro Missale* aus 1603 für deren 60,1 Millionen den Besitzer wechselte. Diese Summen bedeuten eindeutig neue Höchstwerte für Handschriften. Und weitere Rekorde sollten in der Folge erzielt werden. Einen Hammerpreis von 157,7 Millionen Schilling (inklusive aller Abgaben 173,5 Millionen) erzielte das *Porträt des Tieleman Roosterman* von Frans Hals, das laut gut informierten Kreisen der in den USA lebende Österreicher Alfred Bader erworben haben soll.

Es war das Top-Los der Auktion *Sammlung der Barone Nathaniel und Albert von Rothschild*, bei der insgesamt 218 Lose angeboten wurden – und ist nun das teuerste Gemälde des niederländischen Malers. Aber auch ein zweites Werk von Hals, das Österreich im März dieses Jahres zusammen mit 224 weiteren Kunstgegenständen an die Familie Rothschild restituierte, erzielte einen respektablen Preis: Das *Bildnis eines Mannes* kam auf 64,2 Millionen. Eher schwach schnitt hingegen das *Porträt einer Frau* ab: Der Hammerpreis lag bei 19 Millionen Schilling – und damit deutlich unter dem oberen Schätzwert (24,8 Millionen).

Eine Kommode für Louis XVI. von Jean-Henri Riesener wurde von der Gesellschaft der Freunde von Versailles um 148,1 Millionen Schilling gekauft. Und das Gemälde *Erzherzog Leopold Wilhelm in seiner Galerie in Brüssel* von David Teniers II. – es handelt sich dabei um das *Kleine Galeriebild*, das große hängt weiterhin im Kunsthistorischen Museum Wien – ging um 62,5 Millionen an den New Yorker Händler Patrick Cooney.

Aus Österreich waren bloß fünf Käufer erfolgreich, sie gaben insgesamt etwa zwei Millionen Schilling aus. Eine süddeutsche vergoldete Spiegeluhr aus dem 16. Jahrhundert ging für rund 157.000 Schilling an einen Privatmann, die übrigen Käufer gab *Christie's* nicht bekannt.

Die Bundesmuseen aber gingen leer aus: Gerbert Frodl, Direktor der Österreichischen Galerie, hatte zwar das Pouvoir von Kulturministerin Elisabeth Gehrer, für zwei Reliefplatten (Jakob Gabriel Molinarolo zugeschrieben), deren Wert auf 3,2 bis 4,1 Millionen geschätzt wurde, bis zu vier zu bieten, konnte jedoch nicht mithalten.

Auch das Kunsthistorische Museum blieb bei seinen Bemühungen erfolglos, Waffen wie Münzen zu ersteigern. „Wir hatten angesichts der finanziellen Situation keine Möglichkeiten, tatsächlich einzugreifen", so Sektionschef Rudolf Wran. „Wir können nur auf die Möglichkeit der Schaffung einer Nationalstiftung hoffen." (trenk)

Kopf des Tages Seite 40

Lord Hindlip leitet die Auktion: Eine Laute (17. Jahrhundert) erzielt einen Hammerpreis von 1,4 Mio. Schilling. *Foto: APA/Naden*

Wurde bei 530.000 Schilling zugeschlagen: Bemalter Teller von Orazio Fontana aus 1543. *Alle Fotos: Christie's*

Top ten

Folgende Kunstwerke erzielten die höchsten Preise (inkl. Abgaben):

180,4 Mio. S für das *Rothschild-Gebetbuch*, Weltrekord für eine illuminierte Handschrift.

173,5 Mio. S für Frans Hals: *Tieleman Roosterman* Weltrekord für ein Hals-Gemälde.

148,1 Mio. S für eine Kommode aus der Bibliothek von Ludwig XVI.

62,5 Mio. S für David Teniers II.: *Galeriebild Leopold Wilhelm.*

60,1 Mio. S für das *Cornaro Meßbuch.*

48,6 Mio. S für Jan Wynants: *Waldlandschaft mit Jägern.*

46,2 Mio. S für Frans Hals: *Männerbildnis.*

40,5 Mio. S für eine astronomische Standuhr.

33,6 Mio. S für einen persischen Teppich aus dem 16. Jahrhundert.

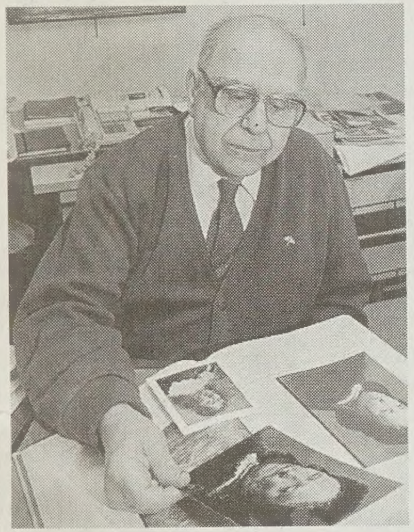
30,1 Mio. S für eine chinesische Kommode von Ludwig XV.

Weltrekord für ein französisches Möbelstück: Die Kommode von Ludwig XVI. erzielte 148,1 Millionen Schilling.

Ein Bild im Gepäck, das nächste Objekt im Auge und die Liebe zur Malerei im Herzen

Wenn Chemie und Kunst zusammenkommen, kann das eine spannende Mischung ergeben: Der Sammler und Händler Alfred Bader ist stets auf der Suche nach Besonderem

Wenn in den großen Auktionen Bilder Alter Meister in New York, London und Amsterdam holländische oder italienische Maler angeboten werden, sieht man häufig einen älteren Herrn von kleiner Statur im Saal, bescheiden, fast etwas nachlässig gekleidet. Neben ihm sitzt oft seine Frau Isabel, auch sie auf den ersten Blick unscheinbar. Man könnte sie für Zuschauer halten, denen es Freude macht, den Kampf um ein Bild zu erleben. Doch der Eindruck täuscht. Alfred Bader verfolgt nicht nur sehr aufmerksam die Auktion, sondern einer von beiden hebt nicht selten auch die Nummer zum Bieten. Als in der großen Auktion Alter Meister im vergangenen Januar bei Christie's in New York das Porträt



Kennerblick: Alfred Bader Foto Archiv

eines stolzen Bürgers in schwarzer Tracht mit weißem Mühlstein-Kragen von Frans Hals ausgeboten wurde, erhielt Alfred Bader bei 900 000 Dollar den Zuschlag. Er hätte auch mehr geboten, denn er wollte dieses Bild haben, weil er von seiner Qualität überzeugt war. Ihn störte nicht, dass das Porträt schon länger auf dem Markt war und in einem schlechten Rahmen unglücklich präsentiert wurde.

Ein halbes Jahr später hatte Bader keinen Erfolg, als er gemeinsam mit dem New Yorker Altmeister-Händler Otto Naumann auf der Rothschild-Versteigerung in London ein weiteres Bild von Frans Hals, das Porträt des reichen Haarlemer Kaufmanns Tieleman Roosterman, kaufen wollte. Der Londoner Händler Clovis Whitfield, mit dem Bader ebenfalls häufig zusammenarbeitet, kaufte es im Auftrag des Kunstmuseums in Cleveland für 7,5 Millionen Pfund. So viel Geld wollte Bader nicht ausgeben – zumal er das in New York erworbene Porträt von Hals für besser hält. Er kauft mit dem Auge und der Erfahrung eines mehr als vierzig Jahre langen Sammlerlebens.

Die Versteigerung der großen Sammlung des Wiener Zweiges der Rothschild-Familie hatte für Alfred Bader besondere Bedeutung. Auch er stammt aus Wien, wo er nach dem Ersten Weltkrieg als Sohn eines ungewöhnlichen Ehepaars geboren wurde. Seine Mutter, die ungarische Gräfin Elisabeth Serenyi, heiratete gegen den Willen ihrer Familie den jüdischen Österreicher Alfred Bader. Die Ehe der Eltern war nicht glücklich. Nach dem frühen Tod seines Vaters wurde der kleine Alfred von dessen Schwester adoptiert; sie wurde für ihn zur Mutter. In seiner Biographie (1995, Weidenfeld and Nicolson, London) erzählt Bader voll Humor und Nostalgie von seiner Jugend in Wien, wo ihn seine Adoptivmutter und eine Gouvernante maßlos verwöhnten und so zu einer Rundlichkeit verhalfen, die bis heute blieb. Das behütete Leben fand ein bitteres Ende, als die britische Regierung in einer Rettungsaktion nach der Kristallnacht Ende 1938 jüdische Kinder aus Österreich und Deutschland aufnahm. Alfreds Adoptivmutter blieb in Wien zurück und kam 1942 im Konzentrationslager um. Zu Kriegsbeginn gelangte Bader als „feindlicher Ausländer" in ein englisches Lager, wurde dann nach Kanada verschickt und durfte dort schließlich 1941 an der Queen's University das Studium der Chemie beginnen. Mit seiner Alma Mater ist er noch heute eng verbunden. Er machte ihr großzügige Stiftungen von Gemälden, hält dort Vorträge über Kunstgeschichte und schenkte ihr sogar ein Schloss in England, in dem die Universität ein internationales Studienzentrum eingerichtet hat. Nach dem Examen an der Queen's University erhielt Bader ein Promotions-Stipendium in Harvard.

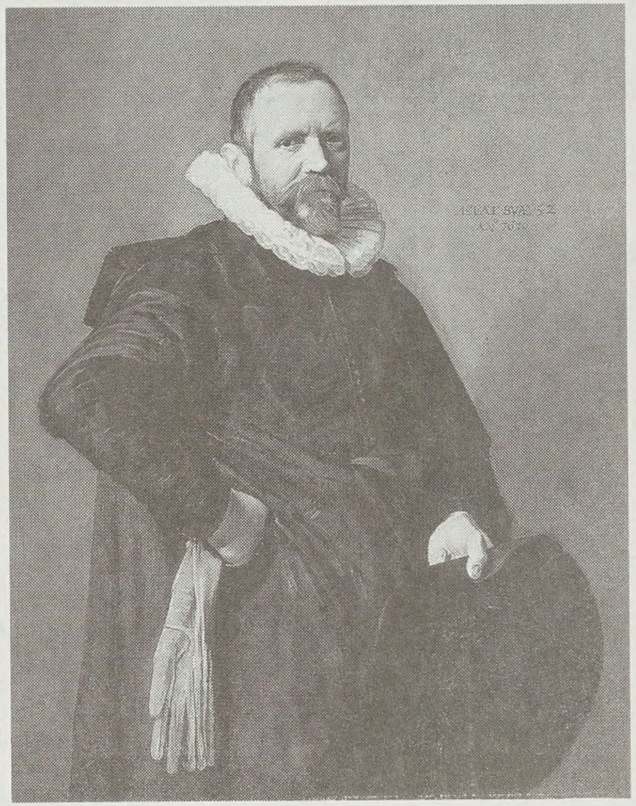
In Milwaukee fand Bader seinen ersten Arbeitsplatz. Hier gründete er jene Firma für Chemikalien, die ihn reich machen sollte. In der amerikanischen Provinzstadt lebt er bis heute als Sammler, Mäzen und Kunsthändler mit einer kleinen Galerie – wobei er selbst schreibt, dass das Verkaufen von Gemäldem aus einer Galerie in Milwaukee ein ziemlich hoffnungsloses Unterfangen ist. Als er 1992 aus dem Vorstand seiner inzwischen an ein anderes Unternehmen verkauften Firma ausschied, hatte er nicht nur die Zeit, sondern auch die Mittel, um sich ganz seiner Leidenschaft, der Kunst und dem Handel, zu widmen. Hatte er sich vorher auf weniger bekannte und weniger teure Werke beschränkt, begann er nun zusammen mit Otto Naumann und Clovis Whitfield Bilder von hoher Qualität und Wert zu kaufen. Das erste solche Werk war ein Porträt des zu seiner Zeit berühmten Pfarrers der holländischen Remonstranten, Johannes Uyttenbogaert, von Rembrandt. Alfred Bader erwarb es 1992 bei Sotheby's in London zusammen mit Otto Naumann für 3,8 Millionen Pfund. Heute hängt es im Rijksmuseum in Amsterdam, das das Gemälde von Bader und Naumann kaufte.

Baders besondere Liebe und Interesse als Sammler und Händler gilt niederländischen Malern des 17. Jahrhunderts. Sie bilden das Schwergewicht seiner privaten Sammlung und seiner Galerie. In Otto Naumann, dem New Yorker Kunsthändler, hat er einen Partner, der ebenfalls Experte auf diesem Gebiet ist, während sein Partner in London, Clovis Whitfield, mehr auf italienische Meister spezialisiert ist. Bader fand früh Kontakt zu den internationalen Autoritäten für niederländische Malerei. So besuchte er bei seinen regelmäßigen Reisen nach Europa immer wieder München. Hier traf er sich mit Walther Bernt, einem der großen Kenner niederländischer Malerei, dessen Gutachten lange Zeit von Sammlern und Auktionshäusern gleichermaßen geschätzt wurde. Zu seinen Freunden zählte auch Ulrich Middeldorf, der bis zu seinem Tod 1983 das Deutsche Kunsthistorische Institut in Florenz leitete. Im Gepäck hat Bader immer Fotos von Bildern, die er gerade gekauft hat, manchmal auch die Werke selbst, um über Zuschreibungen zu diskutieren, Erfahrungen auszutauschen – und nicht zuletzt um zu erfahren, wo gerade interessante Bilder zu finden sind. Ein Schwerpunkt seiner Arbeit ist das Umfeld von Rembrandt, sein Freund Jan Lievens und seine Schüler, unter ihnen Willem Drost und Abraham van Dyck. Doch ist Bader nicht nur Sammler und Händler, er will auch seine Erfahrungen weitergeben, Interesse wecken, zum Sammeln anleiten. So hält er Vorträge in Museen und gibt Vorlesungen an der Queen's University.

Dem agilen kleinen Herrn sieht man kaum an, dass er inzwischen 75 Jahre alt geworden ist. Er nutzt jede Gelegenheit, ein gepflegtes Wiener Deutsch zu sprechen, immer voller Selbstironie. Und immer noch geht er auf Entdeckungsreisen, sucht und findet Bilder, besucht seine wissenschaftlichen Freunde. Mit geschultem Röntgenblick lässt er sich auch von verschmutzten Oberflächen, Übermalungen oder zweifelhaften Zuschreibungen nicht abschrecken. Seit Jahren arbeitet er mit den Restauratoren Charles Munch und Jane Furchgott in Wisconsin zusammen. Als Bader das Uyttenbogaert-Porträt von Rembrandt kaufte, ließ er Munch nach London kommen, um dessen Urteil zu hören. In seiner Autobiographie berichtet er voller Stolz über manch gelungenen Kauf und die damit verbundenen Aufregungen.

Wer Bader in seiner kleinen Galerie im Astor Hotel in Milwaukee treffen will, tut gut daran, rechtzeitig einen Termin zu vereinbaren. Er ist stolz auf seine Galerie und betont, dass man dort auch schon bescheidenere Kunstwerke für wenig Geld finden kann. Doch ist dies nicht der Ort, an dem er seine wichtigen Bilder an Museen und Sammler verkauft. Seine große Liebe zur niederländischen Malerei hindert ihn nicht daran, auch zeitgenössische amerikanische Maler des Realismus zu fördern. Er zählt zu den Amerikanern der ersten Generation, die ihrem Land für die Gastfreundschaft und die Chance zum Erfolg dankbar sind – und sich mit großzügigen Stiftungen revanchieren wollen. JULIANE STEPHAN

Foto Otto Naumann Ltd.



Dieser stolze Bürger war 52 Jahre alt, als er Frans Hals im Jahr 1639 Modell stand: Das verrät die Inschrift „AETAT SUAE 52/ANO 1639" auf dem Porträt, das am 29. Januar 1999 im Rahmen der Altmeister-Auktion bei Christie's in New York als Los Nummer 14 zum Aufruf kam. Das Bildnis des Edelmanns in schwarzer Garderobe mit weißem Spitzenkragen, der in der einen Hand einen Hut und in der anderen ein Paar Handschuhe hält, ersteigerte Alfred Bader für 900 000 Dollar.

FAZ 15. 1. 2000

Gardens open to help Hospice

A WELCOME burst of summer sun on Tuesday brought garden-lovers out in droves in support of St Michael's Hospice.

This year's hospice open gardens programme has been badly hit by the weather.

Tuesday was Bexhill's turn in a programme covering Rother and Hastings and four gardens were open to the public.

Hospice Bexhill area fund-raiser Jenny Tyrrell said: "This is more like it! This is what it should be like. We haven't had the weather so far this season and people have not been turning out."

She was speaking outside St John's Cottage, the Cooden Drive home of Raymond and Pat Jeffery and source of some of the greatest interest.

Visitors found a 300ft long garden, crossed by a stream and encompassing half an acre of horticultural variety.

Raymond Jeffery has a different outlook on a wet summer. "At least it is keeping the lawns green. We measured an inch and a half of rain a couple of weekends ago, three quarters of an inch fell between 8.30 and 10.30!"

Among visitors was Barry Saunders. Raymond and Pat Jeffery bought the house from Barry and Pat Saunders and the men were busy comparing notes about the garden.

John and Helen Shuttleworth's garden at High Branches, off Collington Rise, makes good use of a sloping site with mature trees with the sound of water trickling down a cascade.

Eric and Marjorie Johnson created their garden at Barnhorn Hill, Barnhorn Road from open farmland and it is a firm favourite with garden-lovers.

Bentley in Withyham Road is a large, mature garden of great charm.

Open day attracted 626 people and raised £2,250 for the hospice.

Next Tuesday, the open gardens programme returns to the country with Jacobs Farm, Powdermill Lane, Sedlescombe, the home of Michael and Jennifer Keeling, open from 10.30am to 1pm and from 2pm to 4pm.

▲ JENNY Tyrell with Raymond and Pat Jeffery in their Cooden garden.

Free travel for girl in her fight against cancer

AN eight-year-old girl fighting acute lymphoblastic leukaemia has been given free train travel until her treatment in London finishes.

by STEPHANIE POLAK

Rasha Swais, of Bolebrooke Road, was first diagnosed in May in Jordan where her family were living.

Rasha has been travelling to Great Ormond Street Hospital, London, for chemotherapy and lumbar puncture treatment.

Rasha's mum Adrienne said: "We were living in Jordan and were all set to move back to England because my parents are getting older and we wanted to be near them.

"My husband and I are both theatre nurses. Rasha was born in Jordan. My husband is Jordanian and I met him in Saudi Arabia.

"In May Rasha was diagnosed with ALL and we dropped everything and came back to England straight away.

"We're staying with my parents, who have been fantastic, but are currently looking for a house.

"My daughter and I go up to Great Ormond Street Hospital every Friday by train. We have to be in London for 9am which costs about £50 a day. We couldn't get a cheap ticket because of the early journey.

"I wrote to the manager of Hastings Station asking if there was a cheaper way of doing it. We were given a free travel pass, without anyone even asking for a doctor's note. The free train travel will last until Rasha's treatment finishes. We're really very grateful."

Connex South Central donated the free travel. Station manager Julie Tompkinson said, "We were delighted to help in this matter."

"The team at Great Ormond Street are brilliant and the Conquest has also been wonderful. The community nurse comes to our home to take blood from Rasha so she doesn't have to go to the hospital.

"Rasha's prospects are very good. She's responding well to treatment and is very high spirited. I was told that if you're going to get a leukaemia then this is the best one to get. It's a curable leukaemia with an 80 per cent success rate.

"It's early days and the doctors can't say whether she'll need a bone marrow transplant. At the moment Rasha's having two years of treatment; one year intensive and the following year less intensive. She's starting at St Mary Magdalene's School this September."

Station manager Julie Tompkinson said: "We were delighted to help."

Philanthropist speaks of his £6m 'dream'

THE Bexhill benefactor who gave £6m to save Herstmonceux Castle this week spoke of his "dream."

With his wife Isabel, Dr Alfred Bader **(pictured)** was guest of honour at a reception in the castle ballroom on Sunday.

Queen's University of Canada, for whom Dr Bader bought the castle and grounds, was joining supporters of Herstmonceux Castle in acknowledging Dr Bader's award of the CBE.

Friends who had suggested that Dr Bader's generosity should be acknowledged heard the Lord Lieutenant of East Sussex, Admiral Sir Lindsay Bryson say: "I was delighted when I heard that this lovely castle with its beautiful grounds was to be saved for the community by the generosity of one man — Dr Alfred Bader.

"It is fitting that we should celebrate the award of the CBE to Dr Bader in this fine example of our heritage, saved from desecration by insensitive development through his vision and his wish to do something for his old alma mater, Queen's University of Kingston, Ontario. The international study centre which has been established here fulfils a real need to make it possible for young students to pursue their studies in such inspiring surroundings.

"Dr Bader has gifted the castle and its grounds to the university in perpetuity and he has also refurbished and refurnished it.

"That single gesture would have shown Dr Bader as a quite remarkable man. But when one looks a little more closely one uncovers a truly amazing life story."

Dr Bader escaped the Nazis at 14, coming to Britain under the Kindertransport scheme. He was befriended by a Hove resident and educated in Hove and at Brighton Technical College.

At 16 at the height of the "fifth columnists" scare, he was deported to Canada and interned.

But he was later accepted by Queen's College. Sir Lindsay said: "So began a relationship which led to a brilliant career in chemistry and business."

Dr Bader's autobiography revealed a man of staunch Jewish faith, a brilliant chemist and scholar, an astute businessman "but over and above all that a visionary and a romantic."

Referring to Mrs Bader, a co-founder of Bexhill Museum of Costume and Social History, he said: "Had he not married a girl from Sussex, I doubt if Herstmonceux Castle would have been saved for our two nations. So while we honour Alfred Bader here today and delight in the honour accorded him by Her Majesty, we also recognise the contribution made by his wife Isabel."

Dr Bader said his first grandson was called Isaiah. In the Bible, "the book of dreams," the prophet Isaiah spoke of beating swords into ploughshares.

"All of us have our dreams, usually much more modest. When I was 16 and deported to Canada I dreamt that I would go to college. That dream came true at Queen's University.

"When I built my chemical company I dreamed that it would supply the best research chemicals in the world, and that dream has come true.

"When Isabel and I saw this empty castle six years ago we both dreamt that this become an international study centre for Queen's University.

"We now have three flags flying up above the castle and that dream has come true, thanks to so many of you here today."

Clues from the past

A BROKEN pot may be a clue from the past and a team of experts will help identify odd items picked up from walks on the beach or dug up in the garden, as part of National Archaeology Day on July 25.

The day is organised by the Young Archaeologists Club which encourages children aged nine to 16 to become involved in archaeology.

Bexhill Museum, in common with many others, is to help celebrate the day by holding an identification day.

A team of local experts will attempt to identify any odd pieces found by local people while out and about. There will be free admission to the museum for anyone with a find and teas will be served in the annexe overlooking Egerton Park.

The identification session runs from 2pm to 5pm.

In brief

School success

THE £1,400 success of King Offa Primary School's recent summer fete means that the school has achieved its £5,000 target for improving playground facilities. Work should start during the summer holidays, says headteacher Graham Weston.

Offa inspected

AN Ofsted inspection begins at King Offa Primary School on Monday. Five inspectors are expected to be in the school for a week.

Carnival call

KING Offa School is looking to maintain its record of Bexhill Carnival successes. Parents were being invited to a meeting in the small this week to discuss this year's float for the July 25 procession from Sidley to Polegrove.

Meet the teachers

PARENTS of King Offa Primary School pupils are being invited to meet class teachers at a consultation evening on Tuesday, July 14 and discuss their children's progress.

Final service

AN end-of-term service will be held for King Offa Primary School pupils at St Stephen's Church on the morning of Friday, July 17. School finishes at 3pm.

Children's show

BOTH halls at King Offa Primary School are being used for an exhibition of children's work. Parents are being invited to visit the exhibition after school.

School play

YEAR Six pupils at King Offa Primary School will be staging a play in the school on Thursday, July 16. Space is limited so admission to the 7pm performance is limited to the parents of children taking part. Pupils will have a chance to see the play in school time.

Offa on the net

KING Offa Primary School pupils should be able to access the Internet from every classroom next term. The school is having an ISDN line fitted during the summer holiday and the whole school is being cabled. As part of the Bexhill Regeneration Project, the school is hoping to provide all classrooms with new computers with Internet capability. "Surfing clubs" will develop opportunities for pupils to use the machines after school.

Clubs call

AFTER-hours reading clubs to help children needing extra help with reading are among plans for King Offa Primary School. Now headteacher Graham Weston is appealing via the school newsletter for a "large number" of adults to help with the clubs. The school day at King Offa will finish at 3pm from September.

Hospital help

AN additional member of staff has been recruited at Bexhill Hospital to cope with the increasing number of referrals to the haematology clinic which has pushed up waiting times.

St. Richard's engineers are the brightest in the southern counties!

ST Richard's School's Technology Club is the Southern Counties Regional Young Engineers Club of the Year.

The club's bright youngsters, all aged 15/16, won the Young Engineers for Britain Regional Competition at Ardingly last week.

They competed in the three-day National Finals at the Science Musueum in London this week.

The project entries were: Alan Barry, Light Sensitive Lamp; Michael Freeman, Tech Dolls House; Martin Sheppard, Control-Light Plane; Chris Haragan, BT Office Design; Gareth Batten, Daniel Kent and Callum Collopy-Smith, Money Spinner. The Money Spinner project came second in individual entries for their age group.

Chris Haragon said: "When the results came in for the regional competition we were delighted to hear our school had beaten all others overall."

The Money Spinner design received a highly commended certificate in the Sussex Careers Service Excellence in Partnership Awards.

St Richard's were also highly commended for a Bexhill Education Employers Partnership project, Planning for the Future - the proposed by-pass and northern approach road in Bexhill. The school won the contest, which involved links with industry, against Bexhill High School.

Seen above are Alan Barry, Michael Freeman, Christ Haragon, Victoria Bracken (technology teacher), Daniel Kent and Gareth Batten.

Twist of Dickens

YEAR six pupils at St Mary Magdalene's School demonstrated their fine theatrical skills with a performance of "Dickens With A Twist".

The musical adaptation of Oliver Twist was given to family, friends and local residents in the school hall on Wednesday and Thursday last week.

The ll-year-olds dressed as urchins and ragamuffins in Dickens' famous heart-wrenching tale of orphans and poverty in early 19th century London. Secretary Mrs Cox said: "It was really excellent. The children were all in costume and all the performances were brilliant."

Mrs Wookey finishes on high note

A "SWAN-SONG" concert for retiring head of music Gill Wookey was held at King Offa School on Friday evening attended by staff, parents and invited guests.

Mrs Wookey, who has taught at the school for 19 years, will be sadly missed by staff and pupils alike.

Over 100 pupils, aged six to 11, performed classical, jazz and modern pieces.

Headteacher Graham Weston said: "It was a wonderful evening displaying so many musical talents, all the more special as it was Gill Wookey's final musical concert at the school.

"Gill has been an inspiration to so many children and the climax to the musical entertainment was five ex-pupils returning to sing to Gill and say thank you."

Gill plans to take it easy now she's retired: "I'll have time to relax and unwind and catch up on reading the many books I have collected. I'm also looking forward to gardening, walking and many other things I haven't had the time to do."

Pictures can be ordered from our Sackville Road offices (or ring 434734)