SCIENCE
http://www.aaas.org

Publisher: Richard S. Nicholson
Editor-in-Chief: Floyd E. Bloom
Editor: Ellis Rubinstein
Managing Editor: Monica M. Bradford
Deputy Editors: Philip H. Abelson *(Engineering and Applied Sciences)*; John I. Brauman *(Physical Sciences)*; Thomas R. Cech *(Biological Sciences)*

Editorial Staff
Assistant Managing Editor: Dawn Bennett
Senior Editors: Eleanore Butz, R. Brooks Hanson, Pamela J. Hines, Barbara Jasny, Katrina L. Kelner, Paula A. Kiberstis, Linda J. Miller, L. Bryan Ray, Phillip D. Szuromi, David F. Voss
Associate Editors: Gilbert J. Chin, Suki Parks, Linda R. Rowan
Letters: Christine Gilbert, *Editor;* Steven S. Lapham
Book Reviews: Katherine Livingston, *Editor,* Jeffrey Hearn, *Editorial Assistant*
Editing: Valerie Jablow, *Supervisor;* Cara Tate, *Senior Copy Editor;* Jeffrey E. Cook, Harry Jach, Erik G. Morris, Christine M. Pearce
Copy Desk: Ellen E. Murphy, *Supervisor;* Sherri Byrand, Joi S. Granger, Daniel T. Helgerman, Beverly Shields, Kameaka Williams, *Assistant*
Editorial Support: Sherryf Farmer, *Supervisor;* Brent Gendleman, Carolyn Kyle, Michele Listisard, Diane Long, Patricia M. Moore, Ted Smith
Administrative Support: Sylvia Kihara, Charlene King
Computer Specialist: Roman Frillarte
Telephone: 202-326-6501; **FAX:** 202-289-7562; **TDD:** 202-408-7770

News Staff
News Editor: Colin Norman
Features Editor: John M. Benditt
Deputy News Editors: Tim Appenzeller, Joshua Fischman, Jean Marx, Jeffrey Mervis
News & Comment/Research News Writers: Linda B. Felaco (copy), Constance Holden, Jocelyn Kaiser, Richard A. Kerr, Andrew Lawler, Eliot Marshall, Rachel Nowak, Robert F. Service, Lori Wolfgang (intern)
Bureaus: Marcia Barinaga (Berkeley), Jon Cohen (San Diego), James Glanz (Chicago), Dennis Normile (Tokyo), Wade Roush (Boston)
Contributing Correspondents: Barry A. Cipra, Elizabeth Culotta, Ann Gibbons, Charles C. Mann, Anne Simon Moffat, Virginia Morell, Robert Pool, Gary Taubes
Administrative Support: Fannie Groom
Telephone: 202-326-6500; **FAX:** 202-371-9227; **Internet Address:** science_news@aaas.org

Art & Production Staff
Production: James Landry, *Director;* Wendy K. Shank, *Manager;* Lizabeth A. Harman, *Assistant Manager;* Laura A. Creveling, Scherraine B. Mack, Stephen E. Taylor, *Associates;* Leslie Blizard, *Assistant*
Art: Amy Decker Henry, *Director;* C. Faber Smith, *Associate Director;* Katharine Sutliff, *Scientific Illustrator;* Holly Bishop, *Graphics Associate;* Elizabeth Carroll, Preston Morrighan, *Graphics Assistants*

Europe Office
Editorial: Richard B. Gallagher, *Office Head and Senior Editor;* Stella M. Hurtley, Julia Uppenbrink, *Associate Editors;* Belinda Holden, *Editorial Associate*
News: Daniel Clery, *Editor;* Nigel Williams, *Correspondent;* Michael Balter *(Paris)*, Patricia Kahn *(Heidelberg)*, Richard Stone *(Russia)*, *Contributing Correspondents*
Administrative Support: Janet Mumford; Anna Sewell
Address: 14 George IV Street, Cambridge, UK CB2 1HH
Telephone: (44) 1223-302067; **FAX:** (44) 1223-302068
Internet address: science@science-int.co.uk

EDITORIAL

Multifaceted Chemistry

Humanity's drive to uncover the secrets of life processes and to use this knowledge to improve human existence has led to spectacular advances in the biological and health sciences. Chemistry richly contributes to these advances by helping to increase our understanding of processes at the molecular level, and it provides many of the methods and techniques of biotechnology. However, chemistry is not just an adjunct of biology and biotechnology. It is and always will be a central science in its own right.

Chemists make compounds and strive to understand their reactions. Chemical synthesis, coupled with biotechnology, is well on its way to being able to reproduce many of nature's wonderful complex compounds and also to make unnatural ones. My own interest lies in the much simpler chemistry of hydrocarbons, compounds of the elements carbon and hydrogen. Although this field is considered by many to be of only limited significance, hydrocarbons are essential to our everyday life because they make up petroleum oil and natural gas. Hydrocarbon fuels generate energy and electricity, heat our houses, and propel our cars and airplanes. They are also the raw materials for most man-made substances, ranging from plastics to pharmaceuticals. What nature has given us over the eons, however, humans are rapidly using up. As our nonrenewable reserves diminish in the 21st century, it will be up to chemists to synthesize hydrocarbons on an increasingly large scale and in new and economical ways.

To better use our existing resources and to make our refineries and plants safer and more environmentally responsible, new technologies that build on the results of ongoing fundamental research are needed. Many of the chemical reactions essential to hydrocarbon transformations are catalyzed by acids and proceed through positive ion intermediates, called carbocations. To allow the preparation and direct study of these long-elusive species in stable form, acids billions of times stronger than concentrated sulfuric acid were needed (so-called superacids). Once carbocations had been prepared, their chemistry made rapid strides. It was discovered that in carbocations either three or five (in some cases even six) groups or atoms are simultaneously attached to the core carbon atom. August Kekulé's concept of the limiting tetravalency of carbon was thus extended by the discovery of higher coordinate carbon compounds and of related hypercarbon chemistry. The Swedish Academy, reflecting on the significance of these studies, was moved to say, "to understand carbocations is to understand chemistry."

Understanding of the fundamentals of hydrocarbon chemistry has also led to practical results. We can now improve widely used acid-catalyzed industrial processes as well as develop new ones. An example is the production of improved high-octane and oxygenated gasoline. Toxic and dangerous acids used in refineries, such as hydrofluoric acid, can be modified to make them substantially less volatile and thus much safer. New generations of diesel fuel additives are being developed to allow cleaner burning and less pollution. Ways are being found to convert natural gas directly to liquid hydrocarbons and their oxygenated derivatives. In the long run, we will be able to convert even carbon dioxide from the atmosphere into hydrocarbons if we can find sources of abundant cheap energy (probably safer atomic energy) that allow us to produce the needed hydrogen from seawater. We will then be able to parallel nature's photosynthetic recycling of carbon dioxide and provide for our hydrocarbon needs even after we have exhausted our fossil fuels. The relevant chemistry is already being developed in laboratories such as mine. This process will also lessen any atmospheric greenhouse effect caused by excessive production of carbon dioxide.

Chemistry does not always enjoy the best of reputations. Many plants and refineries are still potentially dangerous and pollute their surroundings. At the same time, however, our society enjoys a high standard of living that few would give up; a standard produced in no small measure by the results of chemistry. Chemistry can and will be able to bring into equilibrium the two goals of providing for our needs and responding to societal environmental concerns. The challenges are great, but I believe we will meet them.

George A. Olah

The author is director of the Loker Hydrocarbon Research Institute at the University of Southern California in Los Angeles. This editorial is adapted from his speech at the Nobel banquet in Stockholm after he was awarded the 1994 Nobel Prize for Chemistry, given in recognition of his work on carbocations.