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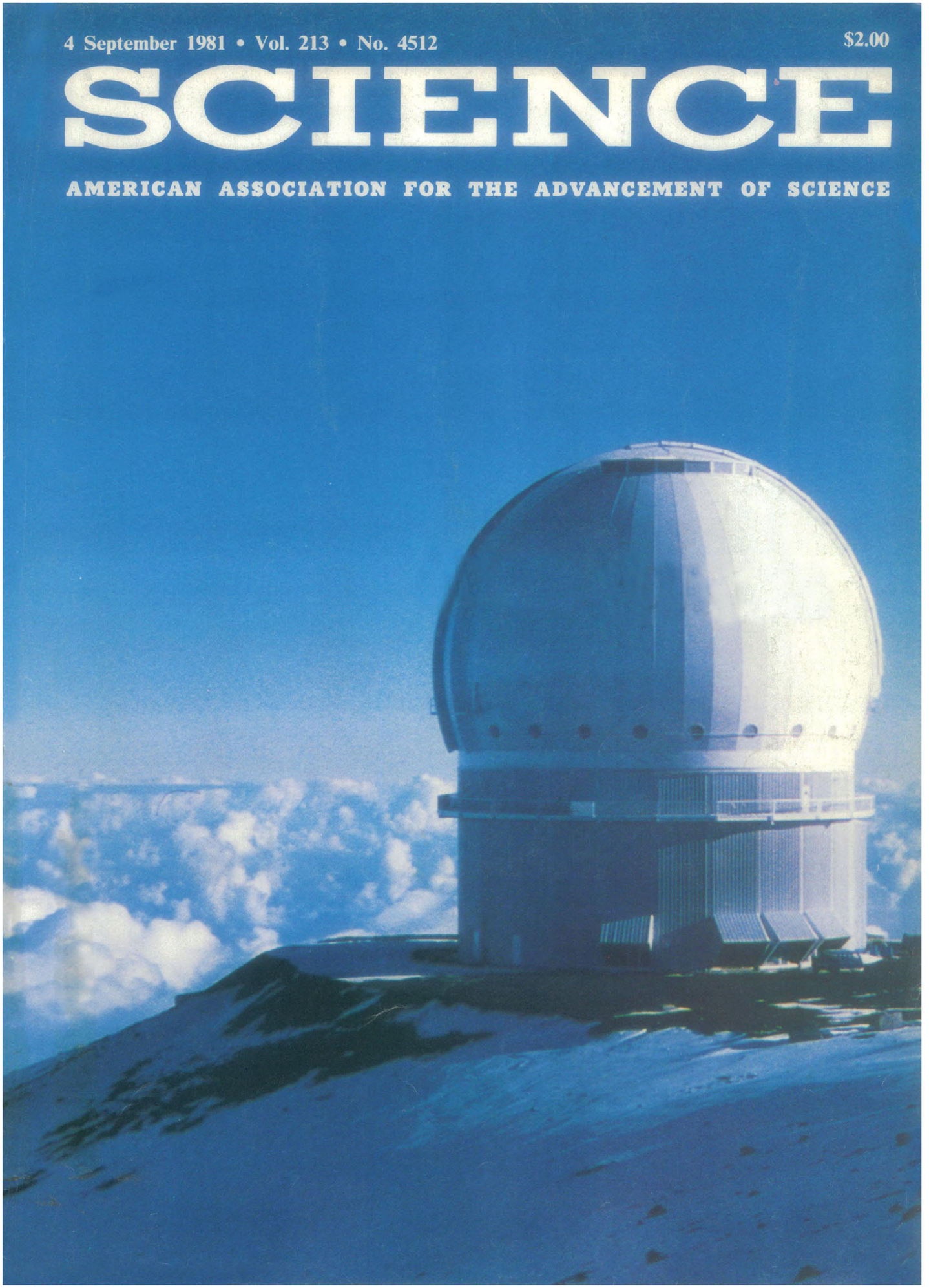

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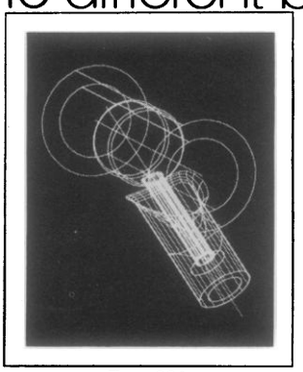

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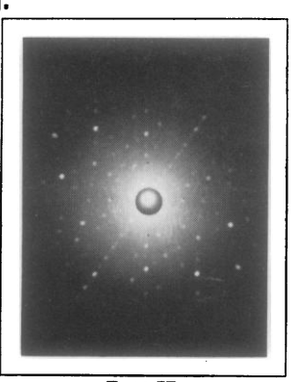

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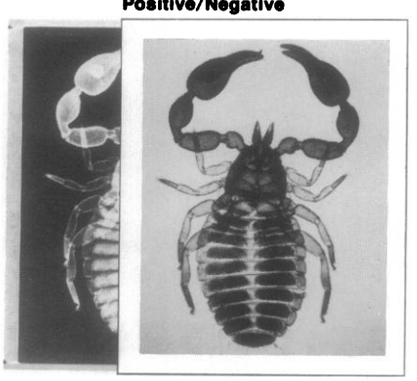

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These authors review the origins of genetic engineering in the science of molecular biology and place in perspective the industrial application and prospective economic impact of this technology.

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THE ARTICLES

- Industrial Microbiology
- Industrial Microorganisms
- The Genetic Programming of Industrial Microorganisms
- The Microbiological Production of Food and Drink
- The Microbiological Production of Pharmaceuticals
- The Microbiological Production of Industrial Chemicals
- Production Methods in Industrial Microbiology
- Microbiology in Agriculture

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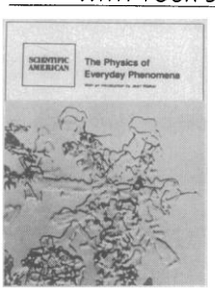

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SCIENCE

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COVER

Optical telescope (Kamuela, Hawaii), international venture of Canada, France, and Hawaii. See page 1065. [Courtesy of René Racine, Canada-France-Hawaii Telescope Corp.]

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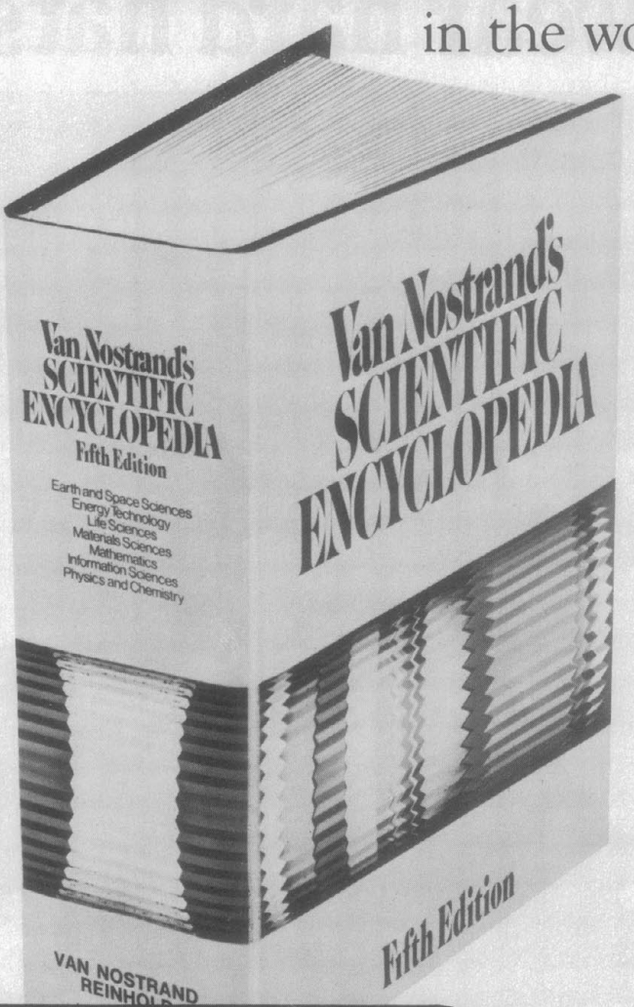

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Some chemical engineers rarely get to wear hard hats.

Film differs from Rembrandt's medium. Most who express themselves with it do not know or care how it is made. Before 1880, no one knew how to make it. Today, no one is remotely interested in using the kind of film made in the 1880s. For today's film is so incomparably more responsive. It contains minute quantities of various molecules we weren't putting in as recently as 1975. And by 1985, we'll probably be putting in other molecules that work even better.

Beauty resides in these molecules themselves. Beautiful also are the methods by which chemical engineers quickly cut the cost of a "new composition of matter" (as patent lawyers put it) so that better film can be widely afforded.

There is practiced here at Kodak a kind of chemical engineering that does not think tonnage. It operates equipment located in small, quiet rooms. It observes biological processes which use membranes for separation in either aqueous or non-aqueous solutions. It often prefers continuous processes to batch processes, as in copolymerizations where the end properties result not from just the ratio of the reactants but from the precision with which they are brought together.

That's why we believe that hardheaded (but not necessarily hard-hatted) chemical engineering is needed in a temple of science like the Kodak Research Laboratories. A fractional-crystallization process like this one needs no scaling up to meet the needs of the factory. But chemical engineering on such a scale is scarcely as common as the analogous fractional distillation that takes place in plumed towers against the sky, a sight which captivated countless photographic artists seeking to depict the essence of industry.

Of course, this isn't the only kind of chemical engineering we practice, but isn't all engineering a bridge between science and art?

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Echoes of Toronto

Those fortunate enough to have attended the AAAS annual meeting held last January in Toronto, the first such held in Canada since that in Montreal in 1964, will each have personal highlights and memories. Among these will clearly be the all-time record low temperatures recorded during the meeting, the stirring strains of Highland pipers welcoming participants to the presidential reception, the warm hospitality of our Canadian hosts and, perhaps most of all, the superb program, organization, and facilities arranged by Tuzo Wilson of the Ontario Science Center and Jack Armstrong of Imperial Oil, cochairmen of the meeting, and their associates.

The success of this AAAS meeting in Canada, and of the meeting in Mexico City in 1974, reemphasizes that we are indeed the *American* Association for the Advancement of Science—and that we still have unfinished business in terms of improving our communication and interaction with other scientific communities in the Americas. The founding of the Interciencia Association following our Mexico meeting marked a first and very important step in that direction.

Science remains, perhaps, the most truly international of all man's activities, transcending national, political, and ideological boundaries. Frequently, indeed, in times of international turmoil, scientific communication has been the only surviving channel linking large segments of the planet's population. This vital interface between science and international affairs was one of the *other* frontiers of science discussed by a panel of four distinguished Canadian scientists, each an internationally recognized leader in his area, in a symposium on this topic at the Toronto meeting. All four of these papers appear in this issue of *Science*.

Frontiers of science are usually understood as those areas wherein the boundaries of human ignorance are being pushed back most aggressively—and most successfully. But these are the internal frontiers of science. No less important are what I would call the external frontiers. Among them are the frontiers discussed in Toronto—those bordering on education, private industry, international affairs, and on the specific questions linking science and technology to development. Excellence in science is a necessary, but far from sufficient, qualification for leadership on these other frontiers; to it must be added wisdom, diplomacy, breadth of experience, sensitivity to other cultures, and the essential spark of creativity that can make things happen. And all of these frontiers are important in today's world.

Disarray is increasingly a characteristic of Western educational systems, particularly in science and technology. In this country we already face serious shortages of trained personnel in physical sciences, mathematics, and engineering, and serious questions concerning the ability of our educational system to respond to these shortages; even more serious is the accelerating decline in scientific literacy among our public.

Ties between science and private industry atrophied during the 1960's as universities responded, sometimes overenthusiastically, to the unprecedented federal support unleashed by perceived national needs in military and space programs. These ties are slowly being reestablished, to the benefit of both universities and industry, but much remains to be done.

And we, like all the developed world, bear a heavy responsibility to work toward sharing our quality of life, in part a reflection of our science and technology, with those less fortunate than ourselves. We have a strong humanitarian motive here; increasingly, this is reinforced by the recognition that to avoid escalating world unrest we must not only be active on this frontier—but also be perceived to be active.

As the only U.S. organization that spans *all* the sciences, AAAS has a unique concern for these frontiers of science. Those discussed in Toronto, and in this issue, are four among many, and the Board of Directors will welcome suggestions for symposiums and other activities pertinent to any of them.—D. ALLAN BROMLEY, *President, American Association for the Advancement of Science*

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