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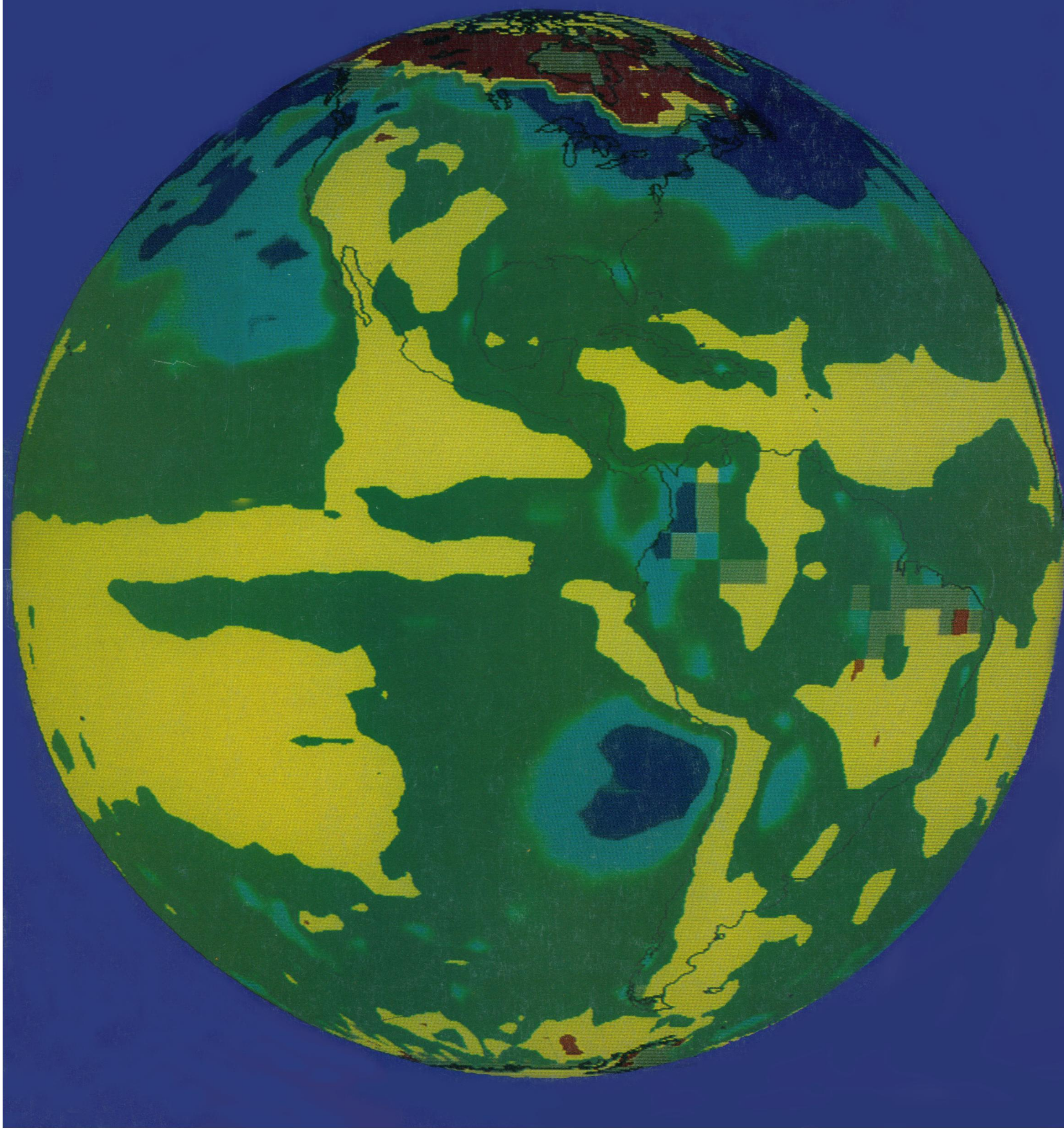

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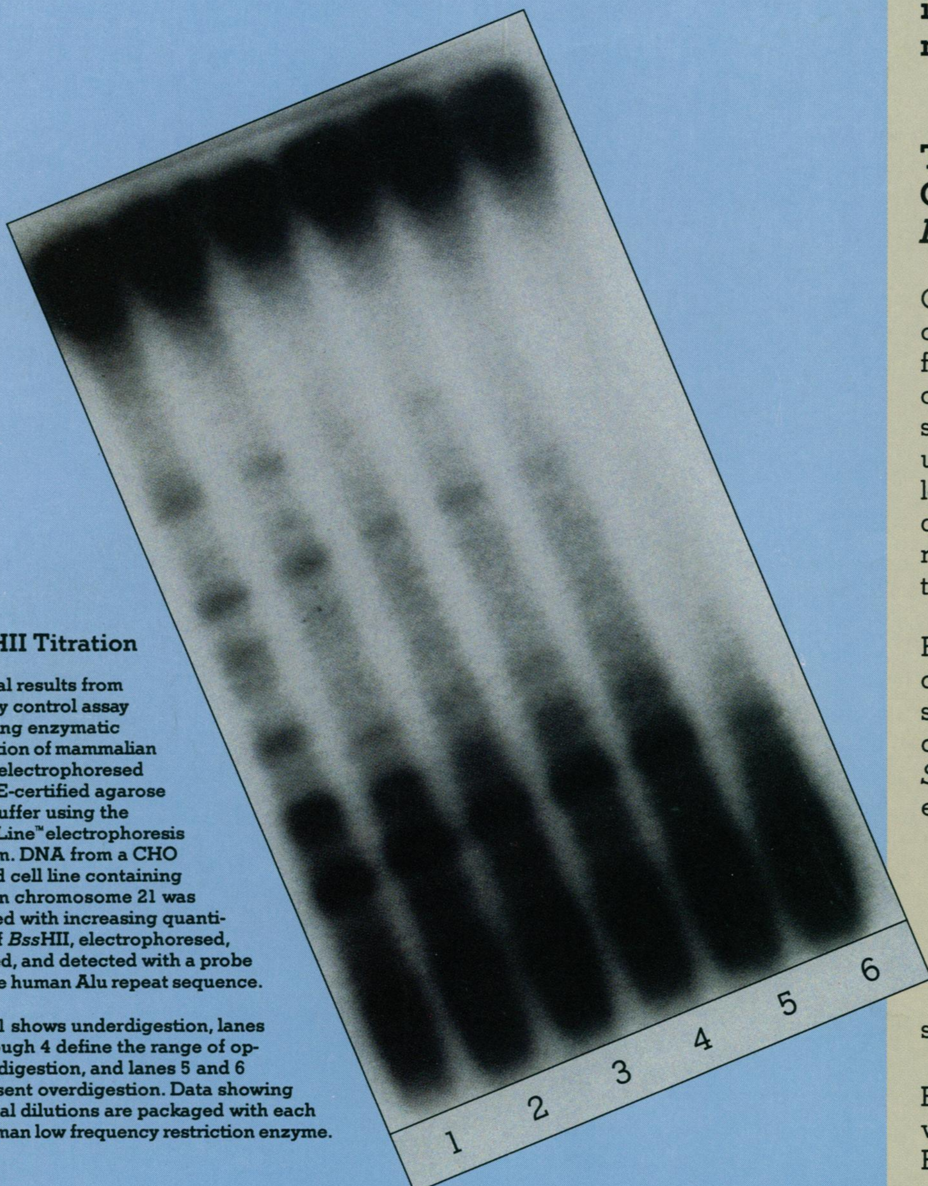

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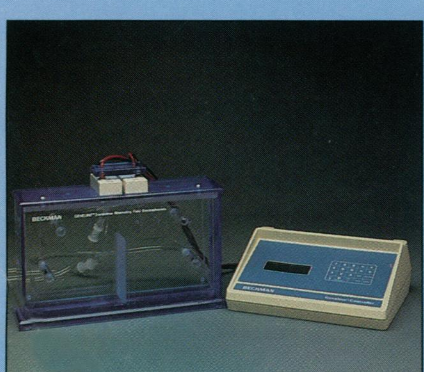

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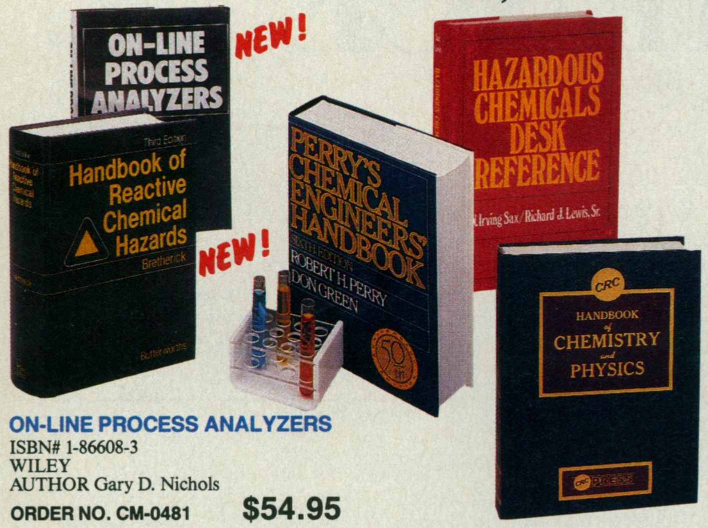

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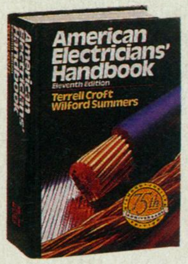

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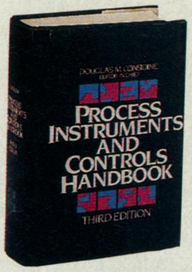

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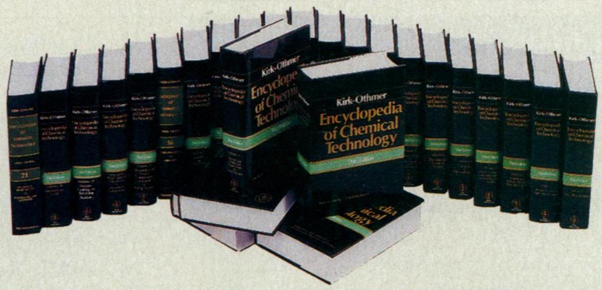

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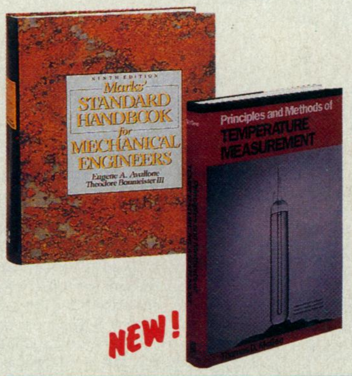

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■ The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objects are to further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.

COVER Depiction of the effect of clouds on the radiative heating of the planet as determined from the NASA Earth Radiation Budget Experiment. Regions where clouds have a cooling effect are shown in green and blue (dark blue, strongest effect). The cooling effect arises because the reflection of solar radiation by clouds exceeds their greenhouse effect. In yellow regions the two effects nearly cancel; rust indicates slight heating. Globally, the satellite data revealed that clouds have a large cooling effect on the radiation budget of the planet. See page 57. [V. Ramanathan *et al.*, Department of Geophysical Sciences, University of Chicago, Chicago, IL 60637; color images processed at NASA Langley Research Center, Hampton, VA 23665]

Reports

Book Reviews

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This Week in SCIENCE

Clouds and climate

How do clouds affect the climate of the earth? Clouds play a complex role: they reflect incoming solar radiation back into space; they also absorb thermal radiation from the earth, reducing the emission of this energy into space. The balance struck among opposing cloud effects varies with a number of (sometimes poorly understood) parameters, including humidity, land versus ocean processes, convection, cloud type (for example, cumulus clouds generally reflect more than they heat whereas cirrus clouds heat more), and others. An experiment that is addressing the relations of clouds, radiation, and climate was begun in 1984 (cover); three orbiting satellites are collecting data on radiation coming to and emitted from the earth. Overall, the Earth Radiation Budget Experiment (ERBE) has shown that clouds tend to cool the earth. Ramanathan *et al.* discuss the ERBE experiment and some of the data that have been collected, the feedback relations that link climate changes and cloud effects, the implications of the data for general circulation models, and the insights that ERBE data will provide about past and future earth climates and climate changes (page 57). Kerr discusses this work in relation to the greenhouse phenomenon (page 28).

Useful superconductors

If the new high temperature superconductors are to be of use for anticipated applications, the compounds must be available as small particles that will sinter well into dense compact structures. Procedures and conditions for synthesizing the requisite small particles of the $YBa_2Cu_3O_{6+x}$ class of superconductors are described by Horowitz *et al.* (page 66). The synthesis was carried out at lower temperatures than those that have been used in previous syntheses (and that have routinely yielded only large particles). Stable intermediates that usually contaminate the end product did not form but the desired precursors did. Chemical and physical analyses confirmed that high transition temperature superconducting compounds (with an onset temperature for superconductivity of 87 K) had successfully been produced.

Phylogenetic relationships

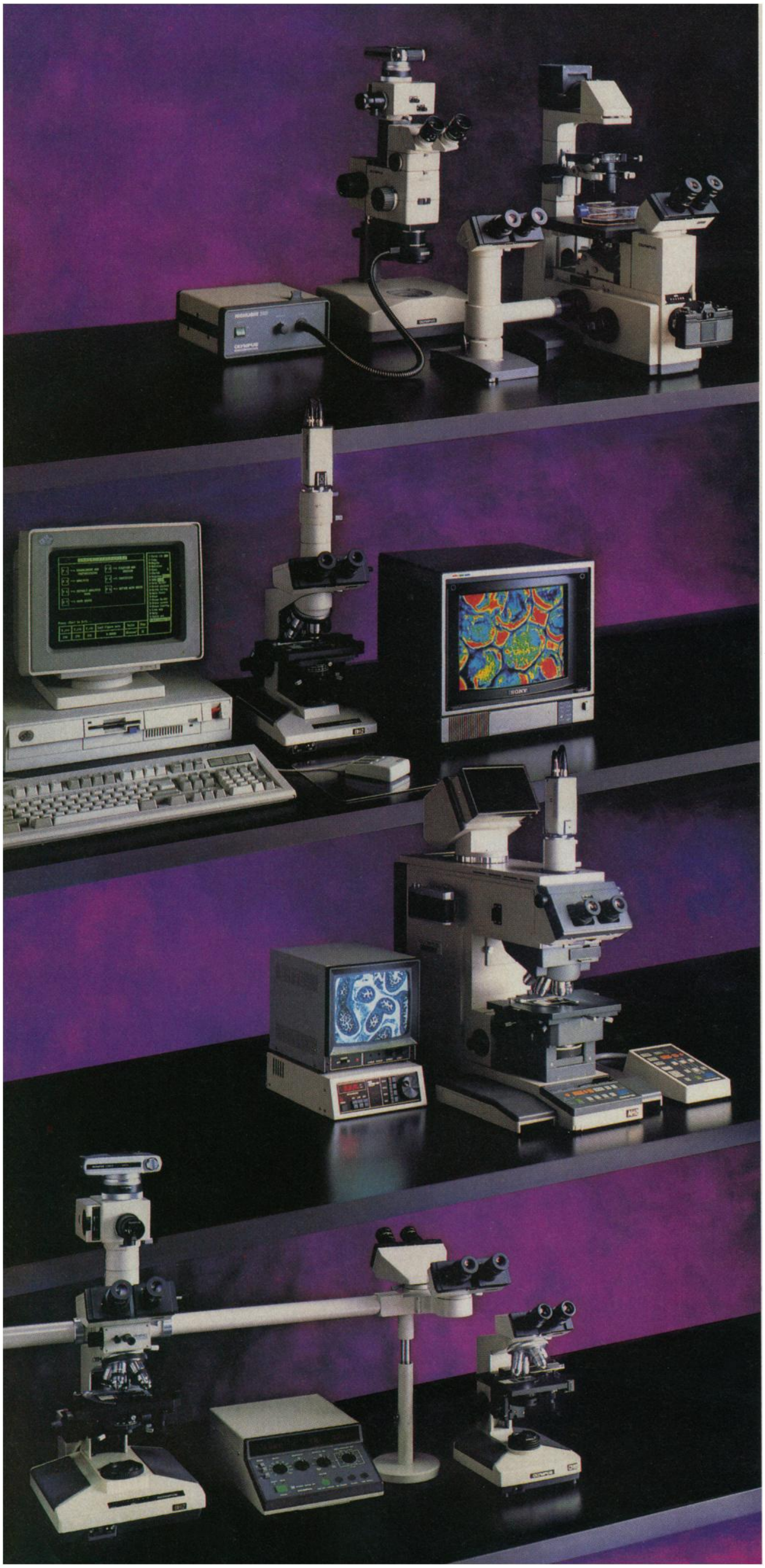
Molecular studies help in the shaping of phylogenetic trees and can sometimes reveal unsuspected relationships among organisms. A study of the so-called 16*S*-like ribosomal RNA of *Giardia lamblia*, a protozoan parasite that can infect humans drinking from contaminated lakes and streams, indicates that, although this organism is a eukaryote, its genetic material is as old as and close in structure, size, and organization to that of prokaryotes (page 75). The sequence of the 16*S*-like ribosomal RNA was determined and compared with small subunits of RNA from a number of other eukaryotes and prokaryotes. *Giardia lamblia* has been placed in the earliest diverging branch of eukaryotes, it shares with certain prokaryotes a number of features besides those common to the ribosomal RNA molecules, and its evolutionary distance from certain other eukaryotes, based on the RNA sequence comparisons, appears to be greater than its distance from some of the prokaryotes. Sogin *et al.* suggest that eukaryotes might better be classified as distinct lineages that diverged within a single kingdom rather than as members of the three classically defined kingdoms of eukaryotes—the animals, plants, and fungi.

Pavlovian immune response

A flashing light and a humming fan can be made to trigger cells of the immune system (mast cells) to release a mediator (protease II) of allergic reactions. This pairing of seemingly unrelated stimulus and response was achieved in rats through associated exposures of the animals to the light and noise (the audiovisual cue) and to egg albumin (an allergenic substance) (page 83). In response to albumin, antibodies of the immunoglobulin E class (the class associated with allergic reactions) were produced and mediators were released from mucosal mast cells. After several training sessions, the audiovisual cue could, alone, induce the release of the mediator. This experimental demonstration that the immune functioning of an animal can be susceptible to Pavlovian conditioning may have many natural correlates. MacQueen *et al.* suggest a number of likely examples, including allergic diseases such as rhinitis and asthma and intestinal diseases of unknown etiologies such as ulcerative colitis, Crohn's disease, and food sensitivities, all of which have previously been suspected of involving associated nervous system and immune system effects.

Auxin and gravitropism

Auxin appears to mediate gravity's signals in plants, causing roots to grow downward and plant stems and leaves to grow upward (page 91). Molecules of RNA (called small auxin up RNAs or SAURs) that are known to be under the regulation of the plant hormone auxin were mapped inside soybean hypocotyls after the seedlings had been reoriented with respect to gravity. Vertical seedlings were positioned horizontally; the lower side grew more quickly than did the upper side until the apex turned upward; thereafter, the two sides grew upward at the same rate. McClure and Guilfoyle found that the SAURs redistributed in the seedling before there was physical (visual) evidence of a response to gravity and that the fastest growth occurred where the most SAURs had accumulated. The SAURs were concentrated in the cortex and epidermal layers of the hypocotyl. A similar redistribution of SAURs is known to occur when exogenous auxin is applied to a seedling. Exactly how gravity induces its effects is not known: it may require the redistribution of endogenous auxin within plant tissues or some other molecular or biochemical events.



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1989 New Year's Resolution: Go to Heaven

In making New Year's resolutions it is imperative not to aim too low. For example, until recently I thought that very few people got into heaven and that editors never made it. A new survey, however, shows that 85 percent of Americans say there is a heaven and 66 percent expect to get there.

Those are staggering figures, as it is my impression that 36 percent of the population is made up of salesmen who call you by your first name before you have even said one word of greeting. Another group (23 percent) consists of the retroactive predictors—the guys who now know that the stock market was bound to crash, that Bush was sure to be elected, and that Japan was destined to corner the chips market. Then there is a group (22 percent) who keep telling us that life was better in "every century but this and every country but our own." Because these individuals seem to have less chance of entering heaven than a camel squeezing into a modern airplane seat, my own chances appear to have risen dramatically, and I have decided to go for it.

As one step toward this goal, I have resolved, for 1989, to become humble. Being humble is not easy for ordinary people, and it is extraordinarily difficult for editors.

One of the conspiracies against humility might be called "the heroism of the arbitrary decision." Sooner or later, anyone in authority is going to be called upon to make an arbitrary decision because time runs out before the facts are in. The first such decision is made with fear and trepidation and with effusive protestations that one hopes it will never happen again. The second time one rationalizes that it is part of the job and that, in fact, a great deal of time and effort were saved by not consulting too many other people. The third time one notices a tendency to regard oneself as the hero cutting the Gordian knot with a brilliance and integrity not given to ordinary mortals.

The second enemy of humility is known as "the euphoria of the adoring multitude." All who have favors to dispense attract a following who will sing solemn songs assuring them that they are doing well. It is not only delightful to hear, but also the human brain is designed to amplify such signals and to diminish or completely eliminate the objections of "the lunatic fringe" who have the effrontery to suggest that one is doing poorly.

Finally, there is "the lure of evangelism," that almost imperceptible shift from a person who is puzzled by the cacaphony of facts, theories, and opinions in the modern world to one who suddenly believes he or she has seen a clear light and is called to impress this new wisdom on those still benighted. For editors this mission can lead to a little twisting of the facts, all with the noblest of motives, to help the public to come to the "right" conclusion.

In thinking how to slay these terrifying dragons, the unlikely idea that the sword of humility might be a powerful weapon emerged after all else had failed. To avoid the "arbitrary decision," a capable staff orchestrating a cadre of loyal reviewers should be ideal if they are given the support and confidence they deserve. To resist the adoring multitude syndrome, both encouragement and criticism are best observed with the smiling skepticism of the distant observer. Cyrano de Bergerac commented that he rose to his best only when surrounded by implacable hostility. The most outlandish criticism often contains a grain of truth, and the songs of praise may be accepted if it is remembered in the deep recesses of the heart that a successful path was often chosen by blind luck.

Finally and most important, a journal such as *Science* needs evangelism, but the goal should be to present as close to the unvarnished truth as it is possible to achieve. As the interface between science and society becomes more important and complex, there must be a journal that is widely respected for presenting, with perception and candor, the developing and changing data and theories of the controversial issues of the day. Evangelism for the truth must be based on the humility that there is no omniscience at the frontier.

It is perhaps symbolic that as the size and competence of the *Science* staff grows, the type in which the editor's name is listed becomes appropriately smaller, and it would be microscopic indeed if the army of anonymous helpers were added to the printed list. An editor must edit gently but carry a big red pencil. This new modesty will astonish my friends, bewilder my critics, and have a salutary effect on *Science*, as I wend my way to heaven. That is why I resolve to be humble in 1989.—DANIEL E. KOSHLAND, JR.


The Viscous Criterion

The Viscous Criterion

Two scientists at the General Motors Research Laboratories have developed a way to predict the probability and severity of impact injuries in the body's soft tissues, including the heart, liver, and the central nervous system. It is an essential step in designing safety systems to reduce such injuries.

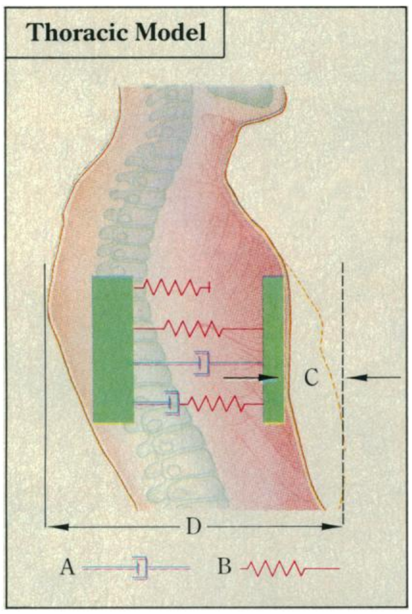
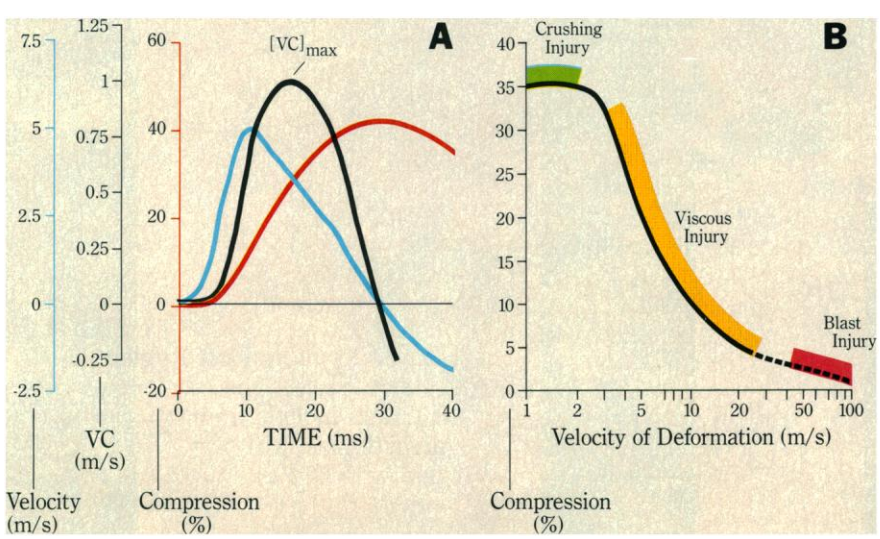


FIGURE 2: Lateral view of a viscoelastic model of the human chest. Dashpot elements (a) and spring elements (b) represent thoracic compliance. Compression (C) is expressed as a percentage of original chest depth (D).

FIGURE 1: A) Plot of viscous response, VC(t), during impact (black). C(t)=normalized compression (red). V(t)=rate of chest deflection (blue). $[VC]_{max}$ defines the Viscous Criterion. B) Range of validity for Viscous Criterion (yellow).



Designing an automobile to reduce the risk of injury to its occupants in a collision demands an ability to correlate the forces generated by the crash with the biological effects experienced by the people involved.

Military rocket sled experiments in the late 1950s measured man's ability to withstand sudden changes in speed. The resulting Acceleration Criterion was used in setting 60g (60 times the force of gravity) as the maximum spinal acceleration allowable under federal motor vehicle standards in a 30 mph crash test.

This Acceleration Criterion treats the body as a rigid structure. Over the years, however, subsequent research on injury mechanisms indicates that injury criteria based on whole-body acceleration are incomplete predictors of injury risk.

The body is a deformable structure, and injury can be sustained when the chest is compressed in an accident. At low speeds of deformation (less than 3 meters per second), the tolerance to rib cage damage and the risk of injury correlate closely to the maximum compression of the chest—expressed as a percentage of the original chest depth from sternum to spine. This Compression Criterion, developed in the early '80s by GM researchers in conjunction with the University of California at San Diego, is useful in evaluating injury risk for safety-belted occupants, where tight coupling to vehicle deceleration reduces the amount of chest compression in a collision.

Doctors Ian Lau and David Viano—both members of the Biomedical Science Department of the General Motors Research Laboratories—began in 1981 to evaluate the importance of velocity in assessing the risk of impact injury. They were concerned that the maximum compression tolerance might underestimate chest injury risk at high speeds of chest deformation (greater than 3 m/s)—typical of unrestrained occupants in a frontal crash, or in high-speed side impacts.

The two scientists designed a series of experiments that held maximum compression constant at 16%—well below the tolerance level of 35%—and varied the rate of abdominal compression from 5 m/s to 20 m/s. The experiments verified that severity of soft tissue injury increased as the velocity of compression increased.

These results, plus further analysis of previous experiments, led Viano and Lau to develop a function called the *Viscous Response* to describe the behavior of soft tissue during an impact event. Viscous Response was defined as the instantaneous product of the velocity of deformation and compression, varying over time: VC(t) (Figure 1A).

The mathematical form of the Viscous Response is derived from analysis of a mechanical analog of the viscoelastic response of the human thorax. (Figure 2). The dashpots (2a) represent the behavior of viscous soft tissue, while the springs (2b) correspond to the elastic skeletal response to impact.

In computing impact energy absorbed by the analog, the dominant term is the product of velocity of deformation and compression, with compression defined as chest deflection normalized by the original chest depth, (Fig. 2, D). Therefore, the Viscous Response is related to absorbed energy.

Drs. Viano and Lau suspected that the injury mechanism for soft tissue was also related to absorbed energy, and designed further experiments to verify the predictive abilities of the peak Viscous Response (VC_{max}). In these tests, velocities of deformation ranged from 5 m/s to 22 m/s and maximum chest compressions ranged from 4% to 55%. Analysis of the test data showed that the maximum Viscous Response was an accurate predictor of injury risk for the entire data set. In addition, VC_{max} was the only biomechanical response that adequately defined injury risk for the full range of test conditions, including the extremes of only 4% compression at 22 m/s, as well as 55% compression at only 5 m/s.

Investigation across this range of deformation velocities effectively links together existing knowledge of crushing injuries, high-speed impact injuries, and data available on blast injuries (Figure 1B).

Applying the Viscous Criterion to previously published blunt frontal impact data, Lau and Viano used statistical analysis to show that VC_{max} was highly correlated with the risk of severe injury. "For velocities of chest deformation above 3.0 m/s," says Dave Viano, "VC_{max} is the principal indicator of injury, whereas for very slow speeds of deflection, the Compression Criterion assesses crushing injury risk. We are, therefore, recommending a viscous tolerance for the chest of VC_{max} equal to 1.00 m/s, and a compression tolerance of C_{max} equal to 35% to minimize the risk of severe injury in an accident."

Ian Lau points out the importance of such risk assessments as targets for automotive designers. "Based on our new awareness of the mechanism of soft tissue injury, General Motors has already designed a self-aligning steering wheel that can be an excellent countermeasure for reducing abdominal injuries in a crash."

The new wheel works in concert with the energy-absorbing steering column, and is available as standard equipment on the 1989 Chevrolet Cavalier. Says Lau, "This is an excellent example of engineering and medical science working together. And because GM is the only auto maker with a biomedical research facility and a dedicated staff of research professionals, it can only happen here."

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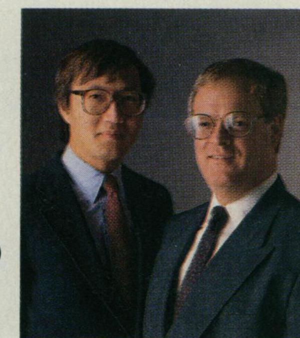

David C. Viano and Ian V. Lau are both members of the Biomedical Science Department at the GM Research Laboratories.

Dr. Viano (right) is a Principal Research Scientist, leading the department's Safety Research Program. Dave received his BS in Electrical Engineering from the University of Santa Clara; he holds both an MS and a Ph.D. in Applied Mechanics from the California Institute of Technology. Dr. Viano joined GM in 1974 following postdoctoral work in Biomechanics at the Swiss Institute of Technology. His interests include technologies to improve occupant protection, the biomechanics of trauma and disability, transportation safety, and public health approaches to injury control.

Dr. Ian Lau came to the Research Laboratories in 1978, and is now a Senior Staff Research Engineer. Ian has a BS in Electrical Engineering from Lowell University. He holds a Ph.D. in Biomedical Engineering from the School of Medicine of the Johns Hopkins University. Ian was also a Postdoctoral Fellow of the American Heart Association at the Hopkins School of Hygiene and Public Health. His other research interests include traumatic cardiac arrhythmias, and occupant interaction with the steering and supplemental restraint systems.

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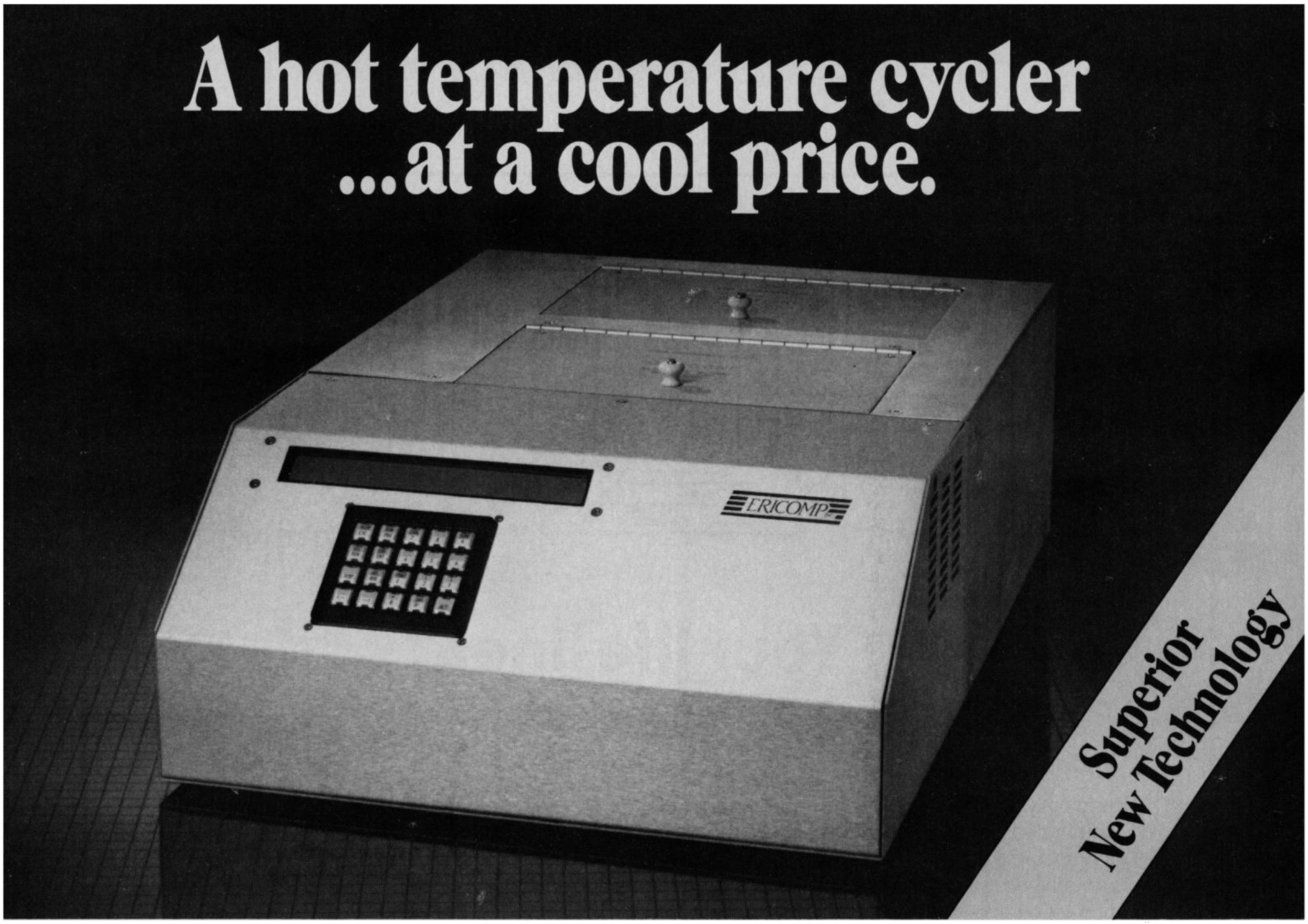

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