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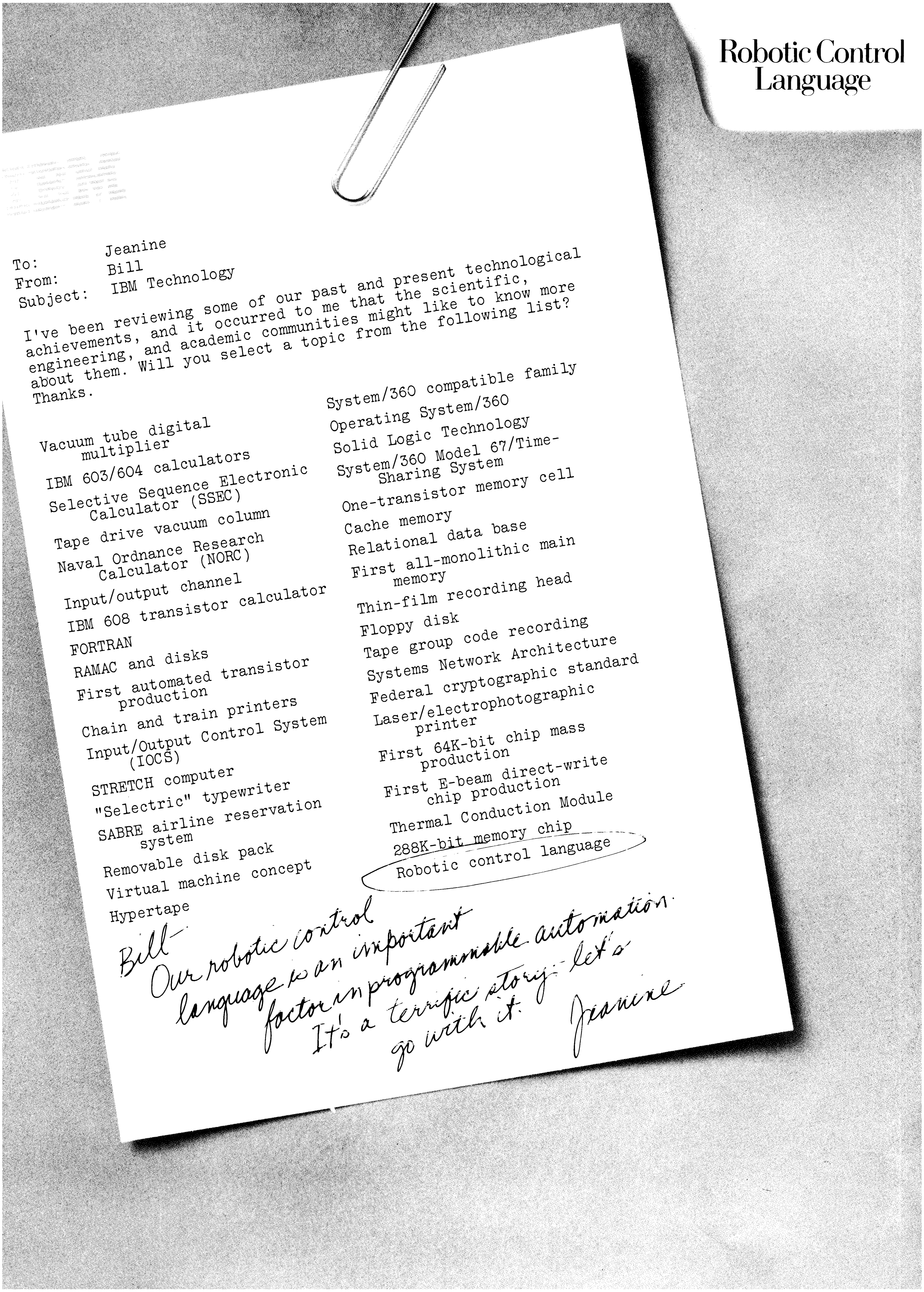
COVER

Demosponge (*Halichondria panicea*) encrusting an intertidal surge channel in Torch Bay, Alaska. Sponge morphology varies in a sophisticated way with wave action. In changing environments, sponges begin production of wave-tolerant tissues more quickly than wave-intolerant tissues. This reduces the risk of catastrophic tissue loss in an unpredictable environment. See page 1478. [S. R. Palumbi, Department of Zoology, University of Washington, Seattle 98195]

Robotic Control Language



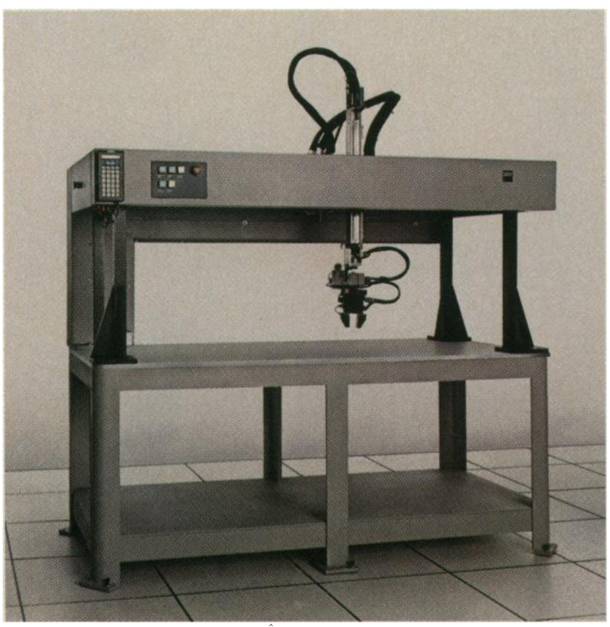
To: Jeanine
From: Bill
Subject: IBM Technology

I've been reviewing some of our past and present technological achievements, and it occurred to me that the scientific, engineering, and academic communities might like to know more about them. Will you select a topic from the following list? Thanks.

- Vacuum tube digital multiplier
- IBM 603/604 calculators
- Selective Sequence Electronic Calculator (SSEC)
- Tape drive vacuum column
- Naval Ordnance Research Calculator (NORC)
- Input/output channel
- IBM 608 transistor calculator
- FORTRAN
- RAMAC and disks
- First automated transistor production
- Chain and train printers
- Input/Output Control System (IOCS)
- STRETCH computer
- "Selectric" typewriter
- SABRE airline reservation system
- Removable disk pack
- Virtual machine concept
- Hypertape
- System/360 compatible family
- Operating System/360
- Solid Logic Technology
- System/360 Model 67/Time-Sharing System
- One-transistor memory cell
- Cache memory
- Relational data base
- First all-monolithic main memory
- Thin-film recording head
- Floppy disk
- Tape group code recording
- Systems Network Architecture
- Federal cryptographic standard
- Laser/electrophotographic printer
- First 64K-bit chip mass production
- First E-beam direct-write chip production
- Thermal Conduction Module
- 288K-bit memory chip
- Robotic control language

Bill—
Our robotic control language is an important factor in programmable automation. It's a terrific story—let's go with it.
Jeanine

Figure 1. *IBM's robotic control language, AML (A Manufacturing Language), is used in all robotic systems that IBM markets. Shown here is the high-end product, the IBM 7565 Manufacturing System, which represents leading-edge technology in intelligent robotics for complex assembly. This system is controlled by an IBM Series/1 computer that monitors manipulator position and sensory feedback 50 times per second, making real-time adjustments if necessary. IBM's mid-range products use AML/Entry, a simplified version of AML, enabling them to be programmed with IBM Personal Computers.*



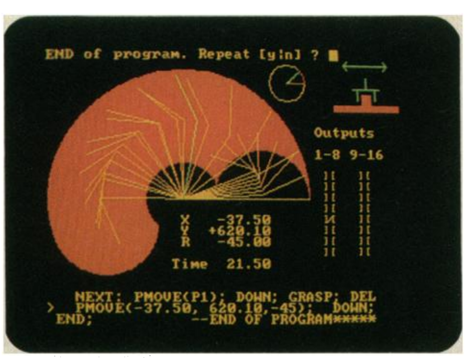


Figure 2. *This display from the AML/Entry Application Simulator is used to check the logic and efficiency of an AML/Entry program, display the robotic arm manipulation (from above), and provide timing estimates.*

Manufacturers everywhere face increasing pressure to produce products of higher quality at lower costs. Today, programmable robotic systems, with their ability to adapt to diverse manufacturing environments, are tools that help meet this challenge.

More than a decade ago, when IBM researchers began investigating flexible automation, they noted that control of manipulation was only one aspect of successful robotic applications; related tasks included terminal and storage input and output, communications, and computation. To integrate all these tasks, they designed a new general-purpose computer language and extended it with functions needed to control a robotic system.

The language that evolved, AML (A Manufacturing Language), is the most advanced robotic control language commercially available today.

In addition to robotic commands such as MOVE, SPEED, and MONITOR—which control motions through sensory feedback—AML has a wide range of communications and data processing capabilities.

AML is able to support different levels of user sophistication because of its structure: a powerful base language designed for functional enhancement through subroutines and application packages. For example, the GRASP subroutine found in many assembly applications is written in AML but is used exactly as if it were a primitive command. Experienced programmers can combine the existing base commands to construct higher-level routines.

AML is an interactive language. It provides the user with the ability to stop a program, check the logical and physical status of the system, change the program, and continue execution. This is critical for efficient development of robotic applications, which must deal with the variability of the real world.

AML has proved to be well adapted for implementing a wide variety of operator inter-

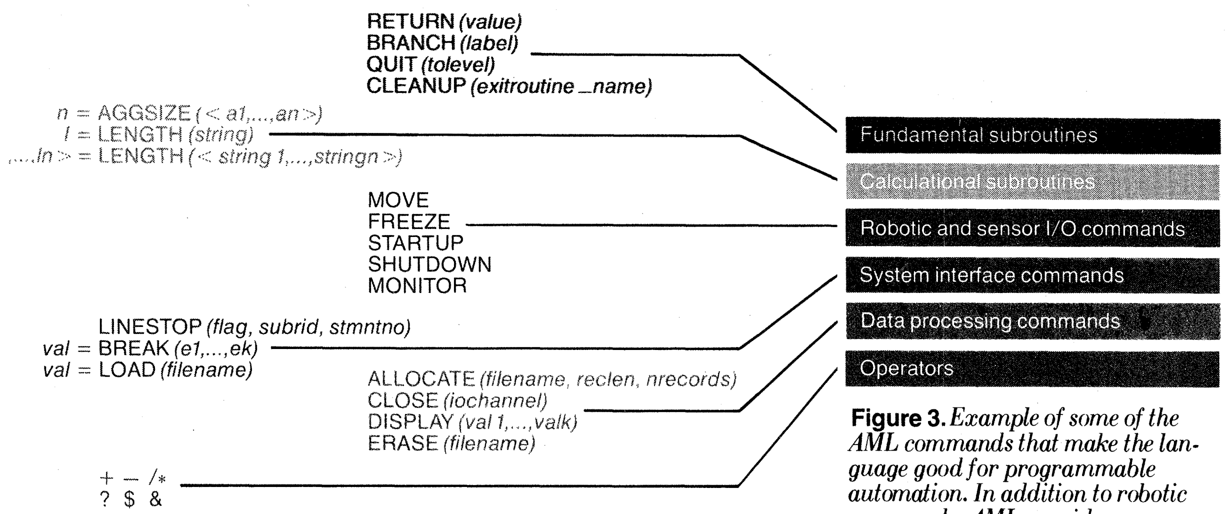


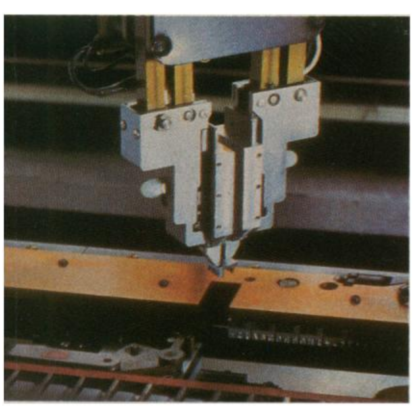
Figure 3. *Example of some of the AML commands that make the language good for programmable automation. In addition to robotic commands, AML provides an abundance of communications and data processing commands.*

aces, including a menu-driven display screen ınd the common "guiding through the motions" nethod. In the latter, the operator moves the nanipulator through the steps of a task by using ı hand-held, push-button pendant. After the ıperator completes the steps, the system auto-natically writes an efficient program in AML.

IBM uses its own robotic technology. For nstance, IBM is working on computer-integrated nanufacturing of typewriters: more than 250 ·obotic units will put together most of the typewriter subassemblies in an automated plant the size of two football fields. In other sites throughout the world, IBM robotic systems are used in such applications as testing circuits, producing cables, and assembling printer type chains.

Many IBM scientists, engineers, and programmers contributed to the development of the innovative robotic control language, AML. Their contributions are only part of IBM's continuing commitment to research, development, and engineering.

For a free technical article about IBM's robotic control language, please write: IBM Thomas J. Watson Research Center Dept. 403D/P3, P.O. Box 218 Yorktown Heights, NY 10598



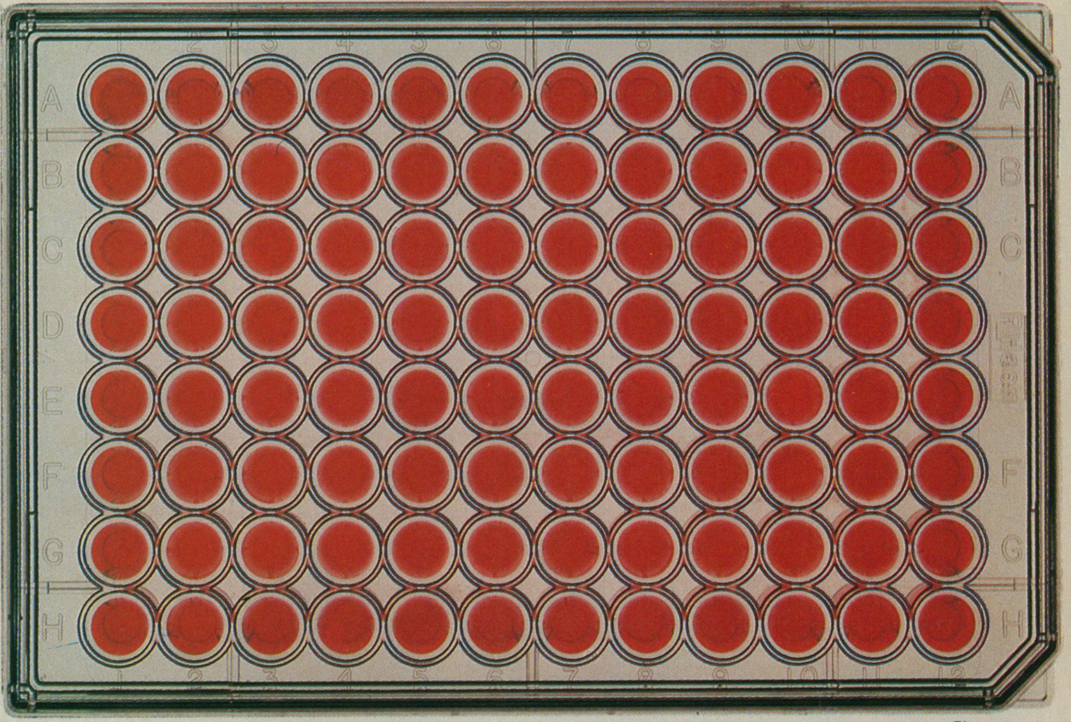
igure 4. *In the automatic assembly of ·pe chains for an IBM high-speed ·inter—one of the many examples of 3M robotic systems at work within the ımpany—an AML program is used to ınsult a data base to determine the ırrect sequence of type slugs. This ɔplication makes extensive use of sens-ıg and programmed error recovery to ısure high reliability.*

```
Step_1:
  CMOVE (<feeder_app(fdr),      --Move to
          feeder_orient, .5>);    grasping
                                  position
  IF DCMOVE (<<0,0,-.75>>,
          ANY_FORCE (2*OZS),
          <.5>) THEN
    BEGIN                       --Hit something
                                  on way in
    DCMOVE (<<0,0,2>>);         --Back out
    OP_CHECK ('jammed');        --Notify
    END;                          operator
Step_2:
  cc = GRASP (0.1,              --Attempt to
          <-.04, .04>,            grasp slug
          PINCH_FORCE (1*LBS));
```

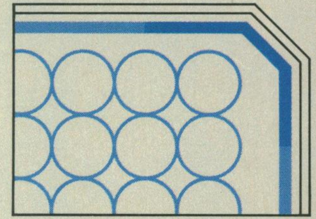
Figure 5. *This is an excerpt of AML code from the program for the application shown in Figure 4. It directs the gripper to open 0.5 inches while approaching a feeder for the next slug of type. It then moves the gripper to the grasping position and grasps the slug with a gripping force of one pound. If an unexpected force is encountered while approaching the feeder, appropriate error-recovery actions are taken.*

Another First From Falcon

Ninety-six ways to cut your losses.



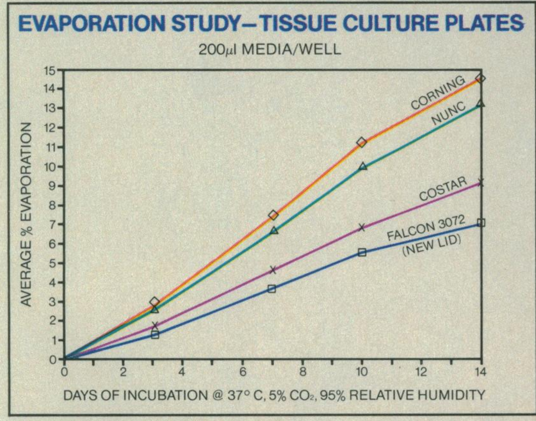
Introducing the Falcon MicroTest™ III 96-Well Plate with the Low Evaporation Lid.
How many times has this happened to you? You culture cells in a 96-well plate and when you examine the



Labyrinth Air Passage System

results, you discover discrepancies between wells of the plate.

This may have happened because either (1) media evaporation in the outer wells differed significantly from that in the inner wells, or (2) the overall plate evaporation was excessive. This evaporation concentrated the media constituents, which in turn caused an increase in their osmolarities. Maybe, out of frustration, you even stopped using



the outer wells altogether.

If this sounds familiar, try the new Falcon MicroTest™ III 96-Well Plate and Low Evaporation Lid (Cat. No. 3072).

There is less media evaporation with Falcon than with these three competitors.
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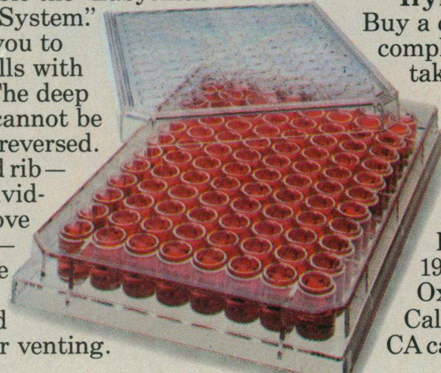
We call the new exclusive design which makes these results possible the "Labyrinth Air Passage System." This allows you to use all 96 wells with confidence. The deep one-way lid cannot be accidentally reversed. The raised lid rib—with the individual rings above all the wells—helps eliminate the chance of cross-contamination and further aids proper venting.



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The sensitive measure of complement activation

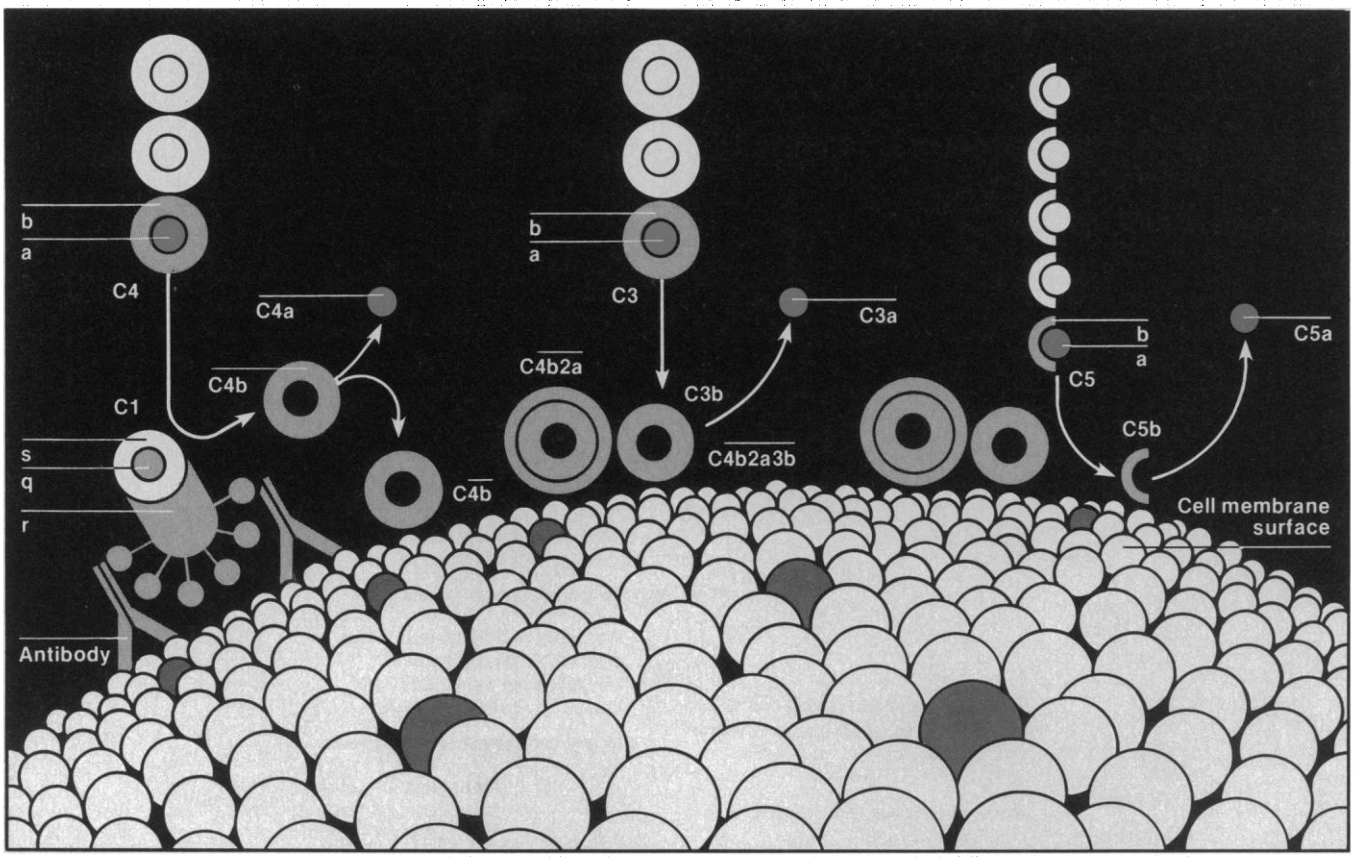

Illustration C3, C4, C5 activation in the classical complement cascade: Activated C1 (C1s), which binds to antigenic sites on the cell surface, cleaves C4 by limited protealysis to yield C4a which is released to the fluid phase and C4b which binds to the surface of the cell. C4b2a cleaves C3 to yield C3a and C3b. The latter binds to the cell surface. Complexes of C4b2a and C3b form a C5 convertase (C4b2a3b) that cleaves C5 to yield C5a, and C5b which binds to the cell surface.

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(1) Hugli, T E, and Chenoweth, D E, "Biologically Active Peptides of Complement: Techniques and Significance of C3a and C5a Measurement," *Laboratory and Research Methods in Biology and Medicine,* (ed. R M Nakamura, W R Dita, E S Tucker III: Alan R. Liss, Inc, 1980), pp.443-460.

(2) Gorski, J P, "Quantitation of Human Complement Fragment C4ai in Physiological Fluids by Competitive Inhibition Radioimmunoassay," *J. Immunol. Methods,* (**47**,1981), pp. 61-73.

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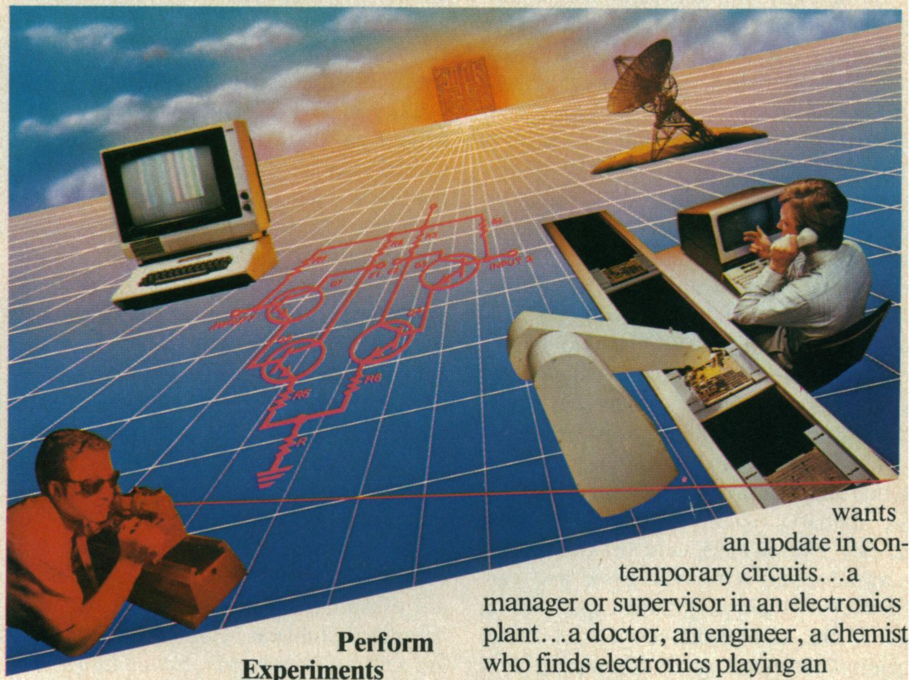

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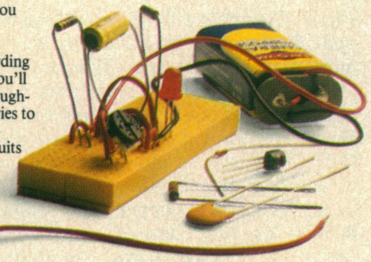

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cations enter solution by hydrogen-cation exchange with the soil exchange complex (*5*). The organic anions are typically removed from solution in the lower soil horizons. When the solution leaves the soil, degassing occurs and CO_2 is lost. The *p*H increases, and the result is a Na^+, K^+, Ca^{2+}, Mg^{2+} bicarbonate stream water with a *p*H greater than 5.5. Krug and Frink do not give sufficient attention to the effect of CO_2 pressure on soil solution and stream water chemistry.

Acid rain adds the additional mobile anions SO_4^{2-}, and often NO_3^- to this system. These are strong-acid anions. The increased concentration of anions in soil solution causes increased concentrations of cations, again regulated by exchange with the soil exchange complex. As the soil solution leaves the soil, degassing of CO_2 occurs, but the water may contain sufficient H^+ to give the H^+, base cation, SO_4^{2-} stream water observed in acidified regions of both Europe and North America (*6*).

Krug and Frink's hypothesis of land-use change does not explain the observed acidification of lakes and streams and loss of fish populations. Apart from natural sea spray chloride in coastal regions, sulfate and nitrate are the dominant anions in these acidified waters. Acid precipitation supplies both. Land-use change in the absence of acid rain can only affect the concentration of the weak-acid anion bicarbonate and organic acids. The concentration of organic anions is negligible in clear waters. Surface waters with appreciable bicarbonate have a *p*H greater than 5.5. Thus land-use changes can affect surface waters only in the *p*H range down to 5.5. Acid rain or some other source of strong acids is necessary to acidify surface waters to a *p*H below 5.5 and to cause the resulting damage to fish populations.

RICHARD F. WRIGHT
Norwegian Institute for Water Research, Post Office Box 33, Blindern, Oslo 3, Norway

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2. D. Drabløs and A. Tollan, Eds., *Ecological Impact of Acid Precipitation* (SNSF project, Norwegian Institute for Water Research, Oslo, 1980).
3. R. F. Wright and A. Henriksen, *Limnol. Oceanog.* **23**, 487 (1978); in *Proceedings of the International Symposium on Sulphur Emissions and the Environment* (Society for Chemical Industry, London, 1979), pp. 277–301.
4. D. W. Johnson, in *Water, Air, Soil Pollut.* **16**, 243 (1981) gives an example from Alaska. Soil waters were as acid as *p*H 4.7, yet stream water had a *p*H of from 6.3 to 6.5.
5. D. W. Johnson *et al.*, *Arctic Alpine Res.* **9**, 329 (1977).
6. R. F. Wright and E. T. Gjessing, *Ambio* **5**, 219 (1976); R. F. Wright, *Nor. Inst. Water Res. Acid Rain Res. Rep. 4/83* (1983).

We are pleased that Johnson *et al.* agree that soil formation is a strongly acidifying process that can contribute to the acidification of landscapes, including those receiving acid rain. This was the major point of our article. Also, Seip and Dillon agree that changes in land use may be important, although Wright argues that such changes cannot acidify surface waters below about *p*H 5.5.

However, there are differences of opinion about the importance of soil organic matter in buffering acidity, as well as the effects of deposition of atmospheric sulfate, and the impact of historical or naturally occurring changes in the landscape. In addition, there are some misinterpretations of our statements or their emphasis. We welcome the opportunity to clarify these issues.

We agree with Johnson *et al.* that the *p*H of a system is an important thermodynamic parameter. The heart of the matter, however, is not the *p*H of the rain, as Johnson *et al.* contend. Rather, the question is, how much does the rain change the *p*H of the soil? Any thermodynamic treatment must include the total acids and bases present in the system because these capacity factors also influence *p*H. As Johnson himself noted earlier (*1*), the potential acid neutralizing capacity of the geologic materials present in the average landscape is enormous. Clearly, this is the most important process controlling the acidity of water, even in areas where acid rain is believed to have a great impact: the majority of waters in these areas are bicarbonate with a *p*H greater than 5.5 (*2–6*) (Table 1). Even most headwaters in sensitive regions are not critically acidified at a *p*H less than 5 (Table 1).

Johnson (*1*) also noted that the rate at which minerals can react with acid rain is critical. We agree. In addition, we emphasized in our article that, in sensitive areas, the buffering capacity of the thin and rocky soils is greatly augmented by the humus that typically develops on such landscapes. While it was generally thought that soil organic matter buffers against additions of strong acids only by cation exchange, it is increasingly recognized that the complex solubility properties of organic matter intimately influence acid buffering capacity both in the soil and in water (*7–10*). The importance of organic matter is illustrated by the high proportion of humic-colored waters in sensitive regions of eastern North America and Scandinavia (*4, 5, 8, 11, 12*). The proportions are even higher for acid lakes: 88 percent of the Norwegian lakes with *p*H less than 5 in Table 1 are

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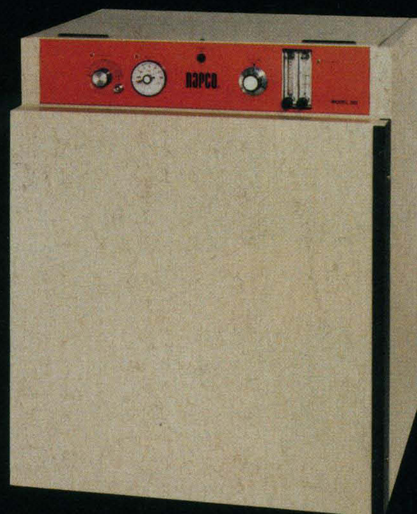

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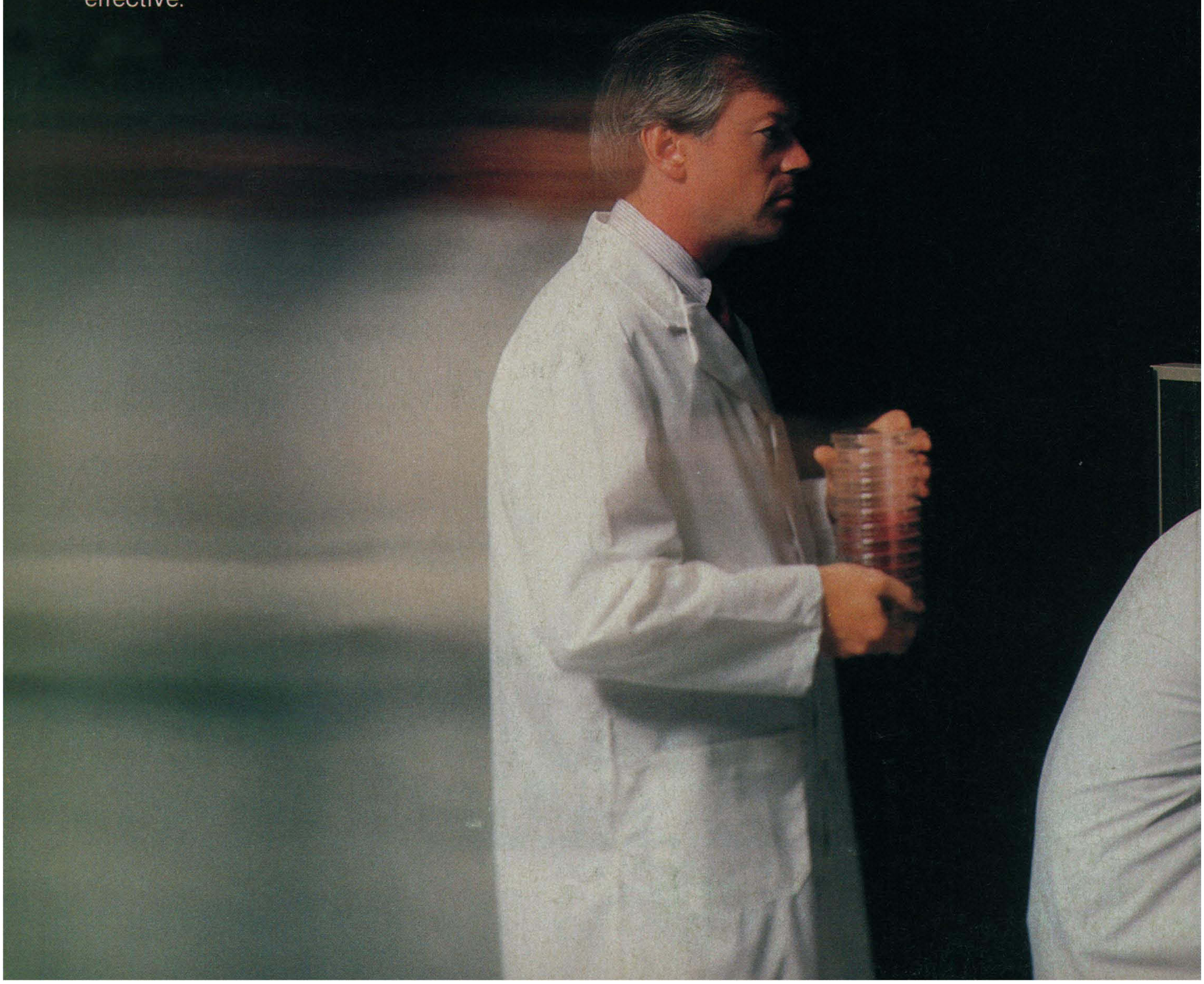

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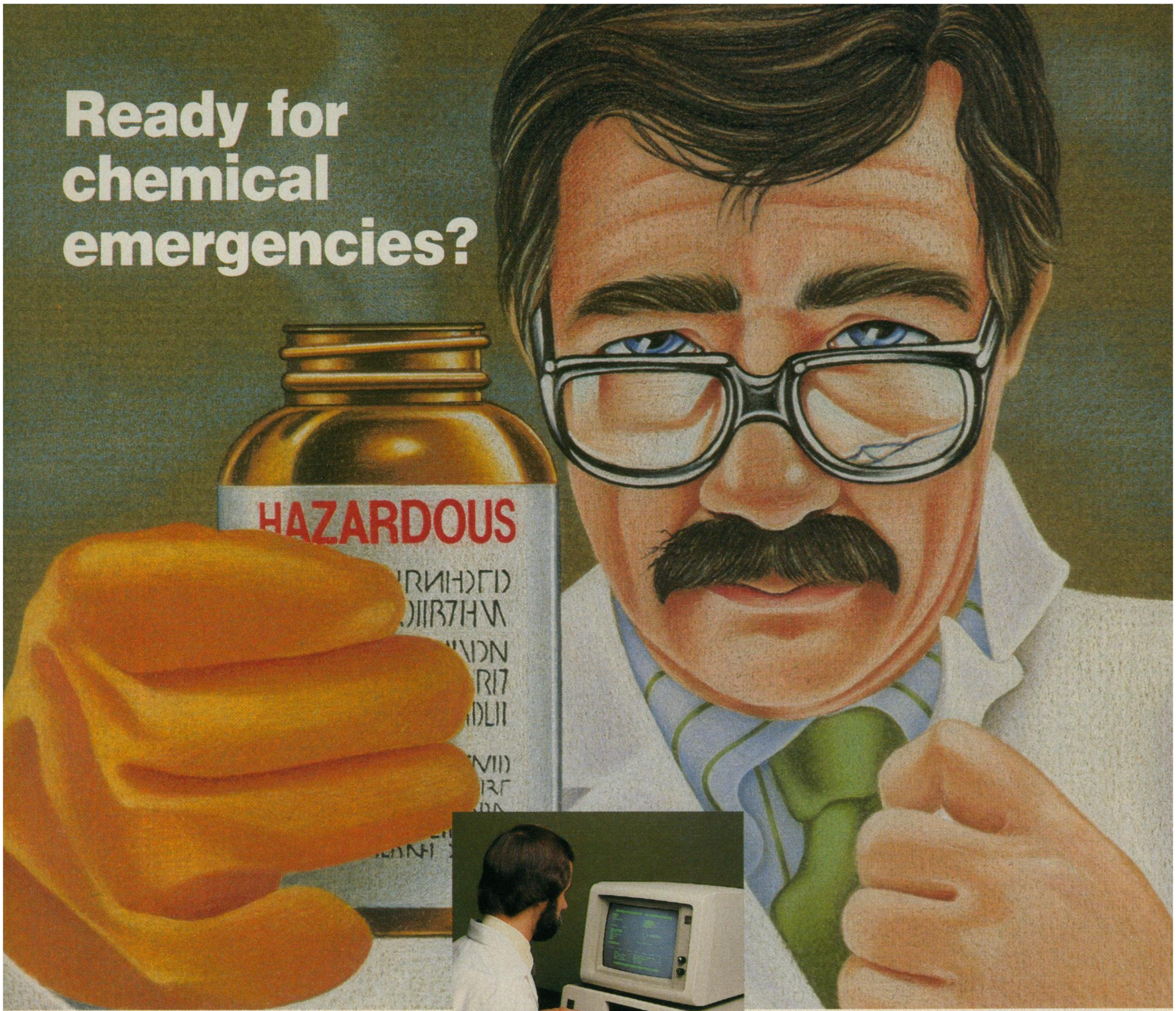

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SCIENCE

New Horizons for the University

A new phase is imminent for American research universities, in which staggering problems and issues—faltering domestic economic productivity, social inequities, unstable foreign relations, and a sagging U.S. share in the international marketplace—mandate new applications of serious, creative intellectual enterprise. One should not be overly expectant about this, but the university's horizon is indeed widening and the potential benefits are real. Alliances between universities and other sectors of society are multiplying, encouraged by some government funding and tax policies and by private sector coalitions such as the Business-Higher Education Forum.

At my own university the trend is felt at all levels. Locally, we have helped to form business-municipal coalitions to confront urban fiscal problems; expanded education to foster international trade and exchanges; created regional data bases as tools for economic planning and expansion; moved toward comprehensive collaboration with school systems; and formed a subsidiary Foundation for Applied Science and Technology to accelerate movement of knowledge from laboratory to marketplace through partnerships with industry. Moreover, we have joined with AT&T Information Systems in a project to create a fiber-optic campus of the future, giving us the capacity for quantum growth in versatile and integrated transmission of audio, video, and digital information.

Increasingly, universities enter into arrangements like these with more hopeful expectancy than apprehension. It is true that as the partnerships multiply the university is presented with a set of deeply introspective questions such as how to meet the demands of public service while encouraging pure scholarship and preserving culture. The values of autonomous investigation and unfettered research were traditionally held aloof from relevance, applications, outreach, and demonstrable public benefits. But this stance is now being questioned. Admittedly difficult problems may be encountered in business and government partnerships, such as maintenance of the openness of university research and avoidance of conflict of interest, but these issues should be challenges for constructive resolution. The problems of society are imperatives for action, and the universities of America are an immense public resource. Their leaders have no choice but to preserve freedom of inquiry while playing a stronger role—even becoming a force—in public service and the formation of public policy.

We must work to ensure that the challenges and opportunities presented by universities' burgeoning new relationships will actually broaden and enhance their historic role. Among U.S. institutions, the university has always stood apart for its ability to accommodate greater diversity within a commitment to common principles. In the decades ahead no goal will be more important to this nation. Adversarial relations such as those of labor, business, and government often debilitate our efforts to compete. In the countries of Western Europe and Japan, industrial objectives, national economic planning, tax and export legislation, and labor policy are normally merged into singular national purpose. Cultural homogeneity is often cited as the essential ingredient.

Nevertheless, our own cultural and economic melting pot is a source of vigor, ingenuity, and creativity that can help return the United States to economic vitality and international leadership. American business management has a characteristic style, involving negotiation and compromise, sometimes faltering, that often leads to breakthroughs. But the advantages of diversity are nowhere more impressive than in the American university where men and women come together in an atmosphere of collaboration, constructive competition, synergy, enterprise, and openness. There is great need for the influence of this expansive yet integrated kind of leadership in the United States today. Properly managed, universities' growing partnerships with many sectors should add a dynamic new force in the revitalization of America.—WESLEY W. POSVAR, *Chancellor, University of Pittsburgh, Pittsburgh, Pennsylvania 15260*

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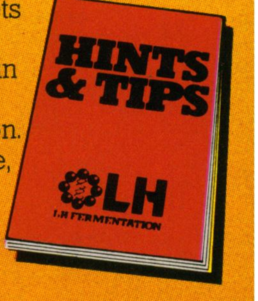

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