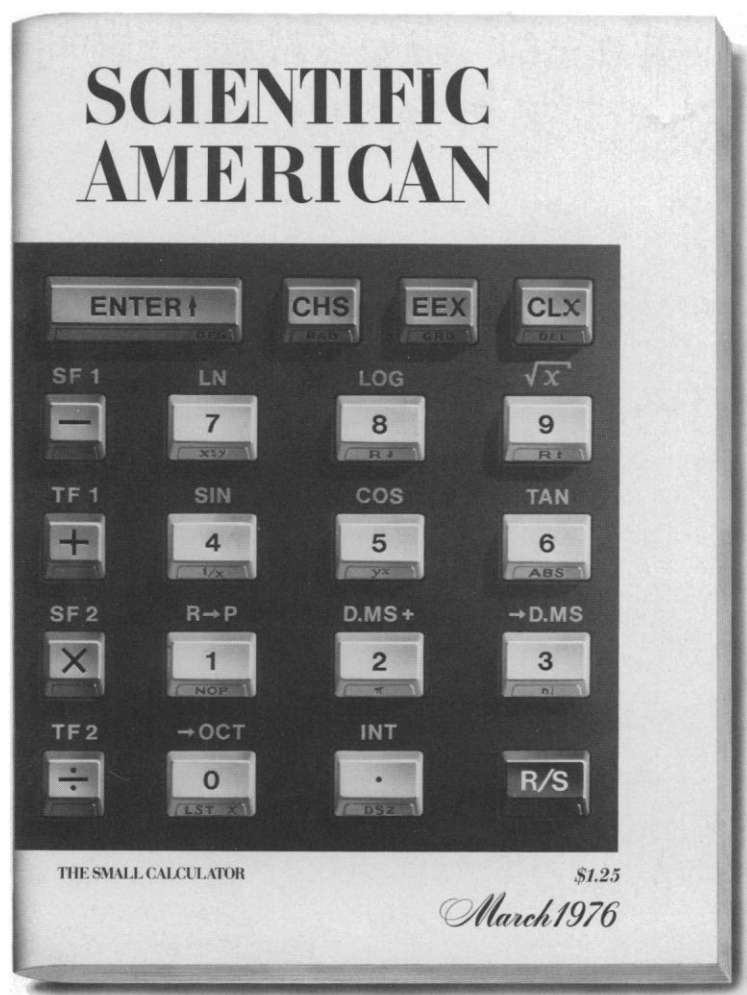


SCIENCE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

5 March 1976, Volume 191, No. 4230





**From the twinkle
in its eye, to the
clock in its heart
...an intimate look
at small electronic
calculators.**

The cover story of the March issue of *SCIENTIFIC AMERICAN* takes you inside a typical small electronic calculator. While it is well known that the hand calculator's working turns on a tiny microelectronic "chip," few realize that the chip contains the major elements of a big computer—a central processor and an active memory. And what about the twinkle (that lights the light-emitting diodes) and the read-only memories called in by the function keys and the 250-kHz main clock (12,000 clock cycles for a simple instant addition)?

"For millions of people," says Eugene W. McWhorter, computer engineer and author of the article, "arithmetic will never be the same again."

For the regular readers of *SCIENTIFIC AMERICAN*, McWhorter supplies the latest installment in a continued story. Starting with "The Transistor" in 1948, we have informed our readers step-by-

step of the advances in hardware and software that have culminated in this hand-held revolution.

The same is true on all the other frontiers of science. Our readers have kept up-to-date with such diverse and profound developments as the recognition of continental drift, the unlocking of the genetic code, the new close-up vision of the solar system, the multiplicity of elementary particles, the discovery of the tool-making ancestors of man, the nerve circuitry that structures human perception.

SCIENTIFIC AMERICAN is the one magazine that offers the reader direct access to the contemporary work of science, written in the language of educated men and women by scientists who did the work reported. (No less than 63 Nobel prizewinners have written for our magazine, most often in advance of their recognition in Stockholm.)

That is why The New York Times calls *SCIENTIFIC AMERICAN*, "This country's and perhaps the world's outstanding forum for communication between scientists and the intelligent public."

And that is why you will want to join our more than 600,000 regular readers.

Use the adjacent postpaid card to begin enjoying the diversity of articles in each monthly issue. A one-year subscription is only \$15. A two-year subscription is \$27, a saving of \$3. And a three-year subscription, at \$37, saves you \$8.

Send no money now. We'll bill you later.

**SCIENTIFIC
AMERICAN**

415 Madison Avenue,
New York, N.Y. 10017

If the card is missing, simply write to
Dept. M, at the address above.

Digital can make your labwork easier by making your lab work harder.

Digital can help make your job easier by making your lab more efficient. No matter whether you're doing experiment monitoring and control. Materials testing. Or spectral analysis.

We offer a complete range of lab hardware. Backed by our Laboratory Applications software. And DECnet networking software. In fact, we offer everything you need to get the most out of our sys-



For low-cost data acquisition, we offer the PDP-11/04.

It's a small yet sophisticated system for data acquisition and analysis on a tight budget. You can use the 11/04 as a smart communication node. A remote data collector. An intelligent terminal. Or a completely independent data acquisition system. With the 11/04, where and how you use it depends on you.

We also offer the GT44 graphics system.

The GT44 combines the power and performance of our disk based PDP-11/40 computer system, intelligent display processor and 17" CRT. It gives you a fast, flexible system for all your interactive graphics applications. The GT44

is hardware and software compatible with the complete Digital 11 family. And that means you can simply add on to your system whenever you're ready. You can even use it as a satellite terminal in your lab network.

For really high speed FORTRAN number crunching, we offer the PDP-11T55. The 11T55 is designed to give you both fast response time and sophisticated program development. It includes two removable disks with 2.4 megabytes each for off line storage of programs and data. A fast floating point hardware processor. And 300 nanosecond cycle time. The 11T55 is ideal for applications that require fast FORTRAN or assembler execution speed.

And you can tie everything together with DECnet.

With DECnet, small systems like our 11/04 can tap the power and memory of larger systems.

Larger systems like our 11T55 or



PDP 11/70 can gather data from small computers connected to instruments. Systems can even swap information and share costly storage devices. In short, DECnet gives you the ability to easily design

your own network in any configuration you choose. So you could save money by (1) sharing resources and

(2) making a system you have work harder.

When you put our cost-effective hardware together with our application and network software, you'll find Digital has a solution to just about any lab application. Even yours.

We'd like to prove it. Just return the coupon below. Digital Equipment Corporation, Marlborough, Mass. 01752, Telephone 617-481-9511, extension 6947. European headquarters: 81 route de l'Aire, 1211 Geneva 26. Tel: 42 79 50. Digital Equipment of Canada, Ltd.

digital

50,000 Computers Saving Managers Millions.

11/04, GT44, 11T55, DECnet ad.

Digital Equipment Corporation, Marlborough, Mass. 01752

☐ I am interested. But my need is long-range. Please send me literature.

☐ I am interested. Please have a sales engineer contact me as soon as possible.

Name _____

Title _____

Company _____

City _____ State _____ Zip _____

5 March 1976

Volume 191, No. 4230

SCIENCE

LETTERS	Diabetes Therapy: <i>L. Koncz</i> and <i>C. E. Zimmerman</i> ; Aerodynamics of the Long Pterosaur Wing: <i>R. S. Stein</i> ; <i>J. H. McMasters</i>	898
EDITORIAL	A Global Rush Toward Nuclear Energy.	901
ARTICLES	Towards a Human Science: <i>M. Mead</i>	903
	The Capsian Escargotières: <i>D. Lubell</i> et al.	910
	Californium-252 Plasma Desorption Mass Spectroscopy: <i>R. D. Macfarlane</i> and <i>D. F. Torgerson</i>	920
NEWS AND COMMENT	Genetic Screening: States May Be Writing the Wrong Kind of Laws	926
	Rocky Speaks at AAAS Meeting	927
	Oil Drilling in the Beaufort Sea: Leaving It to Luck and Technology	929
	Basic Research Funding: ERDA De-energizes Nuclear Science	931
	Hail Suppression up in the Air	932
RESEARCH NEWS	Metallurgy: Extraordinary Alloys That Remember Their Past	934
AAAS NEWS	1975 AAAS Awards Presented in Boston; New Publications; Nominations Invited for 1976 Awards and Fellows	937

BOARD OF DIRECTORS

MARGARET MEAD
Retiring President, Chairman

WILLIAM D. MC ELROY
President

EMILIO Q. DADDARIO
President-Elect

RICHARD H. BOLT
KENNETH B. CLARK

JOEL COHEN
RUTH M. DAVIS

CHAIRMEN AND SECRETARIES OF AAAS SECTIONS

MATHEMATICS (A)
Stanislaw M. Ulam
Truman A. Botts

PHYSICS (B)
Freeman J. Dyson
Rolf M. Sinclair

CHEMISTRY (C)
Henry A. Hill
Leo Schubert

ASTRONOMY (D)
Robert B. Leighton
Arlo U. Landolt

PSYCHOLOGY (J)
Wilbert J. McKeachie
Edwin P. Hollander

SOCIAL AND ECONOMIC SCIENCES (K)
William H. Sewell
Daniel Rich

HISTORY AND PHILOSOPHY OF SCIENCE (L)
Kenneth F. Schaffner
George Basalla

ENGINEERING (M)
Walter R. Hibbard, Jr.
Paul H. Robbins

EDUCATION (Q)
Mary Budd Rowe
James T. Robinson

DENTISTRY (R)
James K. Avery
Sholom Pearlman

PHARMACEUTICAL SCIENCES (S)
Joseph P. Buckley
Raymond Jang

INFORMATION, COMPUTING, AND COMMUNICATION (T)
Burton W. Adkinson
Joseph Becker

DIVISIONS

ALASKA DIVISION
Donald W. Hood
Chairman, Executive Committee

Keith B. Mather
Executive Secretary

PACIFIC DIVISION
Richard Walker
President

Alan E. Leviton
Secretary-Treasurer

SOUTHWESTERN AND ROCKY MOUNTAIN DIVISION
M. Michelle Baker
President

Max P. Dunford
Executive Officer

SCIENCE is published weekly, except the last week in December, but with an extra issue on the fourth Tuesday in November, by the American Association for the Advancement of Science, 1515 Massachusetts Ave., NW, Washington, D.C. 20005. Now combined with *The Scientific Monthly*. Second-class postage paid at Washington, D.C. and additional entry. Copyright ©1976 by the American Association for the Advancement of Science. Member rates on request. Annual subscription \$50; foreign postage: Canada \$10, Americas \$12, overseas \$14, air lift to Europe, \$30. Single copies \$2 (back issues \$3) except Materials Issue (20 Feb. 1975) is \$3 and *Guide to Scientific Instruments* is \$6. School year subscription: 9 months \$37.50, 10 months \$41.75. Provide 6 weeks' notice for change of address, giving new and old address and zip codes. Send a recent address label. Science is indexed in the *Reader's Guide to Periodical Literature*.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

BOOK REVIEWS	The Siamang in Malaya, Social Dynamics of Gelada Baboons, Dominance and Reproduction in Baboons (<i>Papio cynocephalus</i>), reviewed by R. H. Tuttle; Childhood in China, S. M. Olsen; Petroleum and the Continental Shelf of North-West Europe, F. G. Stehli; Rheometry, A. Acrivos	939
REPORTS	Triassic Pollen Date Moroccan High Atlas and the Incipient Rifting of Pangea as Middle Carnian: H. L. Cousminer and W. Manspeizer	943
	Field Evaluation of Benzopyrene Hydroxylase Induction as a Monitor for Marine Petroleum Pollution: J. F. Payne	945
	H Blood Types in Pigs as Predictors of Stress Susceptibility: B. A. Rasmusen and L. L. Christian	947
	Dimethyl Disulfide: An Attractant Pheromone in Hamster Vaginal Secretion: A. G. Singer et al.	948
	Coordinated Activities of Middle-Ear Laryngeal Muscles in Echolocating Bats: P. H.-S. Jen and N. Suga	950
	Perceptual Illusion of Rotation of Three-Dimensional Objects: R. N. Shepard and S. A. Judd	952
	A Line, Not a Space, Represents Visual Distinctness of Borders Formed by Different Colors: B. W. Tansley and R. M. Boynton	954
	Fishes in Oxygen-Minimum Zones: Blood Oxygenation Characteristics: E. L. Douglas, W. A. Friedl, G. V. Pickwell	957
	Epoxide to Olefin: A Novel Biotransformation in the Rumen: G. W. Ivie	959
	Antagonism of Stimulation-Produced Analgesia by Naloxone, a Narcotic Antagonist: H. Akil, D. J. Mayer, J. C. Liebeskind	961
	Photoreceptor-Bipolar Cell Transmission in the Perfused Retina Eyecup of the Mudpuppy: R. F. Dacheux and R. F. Miller	963
	Horizontal Cell Potentials: Dependence on External Sodium Ion Concentration: G. Waloga and W. L. Pak	964
	Selenium in Fly Ash: W. H. Gutenmann et al.	966

MIKE MC CORMACK FREDERICK MOSTELLER	CHAUNCEY STARR CHEN NING YANG	WILLIAM T. GOLDEN Treasurer	WILLIAM D. CAREY Executive Officer
GEOLOGY AND GEOGRAPHY (E) Helen L. Cannon Ramon E. Bisque	BIOLOGICAL SCIENCES (G) Edwin L. Cooper Jane C. Kaltenbach	ANTHROPOLOGY (H) Daniel G. Mandelbaum Philleo Nash	
MEDICAL SCIENCES (N) Harold Wayland Richard J. Johns	AGRICULTURE (O) Orville G. Bentley J. Lawrence Apple	INDUSTRIAL SCIENCE (P) Burton V. Dean Robert L. Stern	
STATISTICS (U) Emanuel Parzen Ezra Glaser	ATMOSPHERIC AND HYDROSPHERIC SCIENCES (W) Fred D. White Stanley A. Changnon, Jr.	GENERAL (X) Gordon J. F. MacDonald Joseph F. Coates	

COVER

Dancer in an origin myth ceremony representing a mythical ancestral wind rearranging islands of floating grass which are the land. Iatmul, Tabunanam Village, East Sepik District, Papua New Guinea. Photograph by Gregory Bateson, 1938. See page 903. [Source for 3(a) Plate XIX(A) from *Naven*, second edition, by Gregory Bateson (Stanford University Press, Stanford, 1958)]

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 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. Postmaster: Send Form 3579 to SCIENCE, 1515 Massachusetts Avenue, NW, Washington, D.C. 20005.

as in birds or the uropotagium (tail membrane) in bats. The Late Cretaceous reptiles appear to have been highly efficient and uniquely structured slow, but maneuverable, flapping animals—the product of 150 million years of reptilian adaptation to flight.

ROSS S. STEIN

Department of Geology,
Stanford University,
Stanford, California 94305

References

1. R. S. Stein, *J. Paleontol.* **49**, 534 (1975).
2. E. H. Hankin and D. M. S. Watson, *Aeronaut. J.* **18**, 324 (1974).
3. C. D. Bramwell and G. R. Whitfield, *Philos. Trans. R. Soc. London Ser. B* **267**, 503 (1974).
4. J. Gray, *Animal Locomotion* (Weidenfeld & Nicolson, London, 1968).
5. C. H. Greenewalt, *Smithson. Misc. Collect.* **144** (No. 2), 1 (1962).

I read with interest the exchange between Greenewalt and Lawson regarding the wing design of the "Texas pterosaur" (*Quetzalcoatlus northropi*). Lawson is quite correct in pointing out the structural dissimilarity between the wings of birds, bats, and pterosaurs. The structure of the latter for the specific case of *Pteranodon ingens* and the corresponding aerodynamic and operational consequences have been fully discussed by Bramwell and Whitfield (1). No bird or bat appears to be an adequate paradigm for deducing pterosaur structure or performance.

What I find surprising in these discussions is that no one seems to have noticed that the wings of large pterosaurs appear to be direct natural counterparts of the National Aeronautics and Space Agency's high aspect ratio *cylindrically cambered* Rogallo wing, examples of which have been extensively flown as hang gliders for several years (2). The largest man-carrying hang glider of this type is presently the "Cronk V" with a span of 11.8 meters and loaded mass of 100 to 120 kilograms.

I have great respect for Greenewalt's earlier work (3) and have made extensive use of it in my own research (4) related to clarifying the interface between natural and low-speed, man-made flying devices (for example, hang gliders, man-powered aircraft, and sailplanes). On the basis of Greenewalt's data and mine, it appears that there is a remarkably good "square-cube law" relation between wing area (S , in meters) and loaded mass (M , in kilograms) for devices covering 12 orders of magnitude in mass (that is, small insects through large transport aircraft). The general trend for "conventional" flying devices is approximately

$$M = 15 S^{3/2}$$

However, for low-wing loading "ultralight" types (for example, butterflies, the zinnia seed, *Pteranodon*, and hang gliders) the corresponding relation is

$$M = (1.2 \pm 0.6) S^{3/2}$$

For soaring birds and sailplanes the relation is about

$$M = (10 \pm 2) S^{3/2}$$

The relation between mass and wing area is directly related to flying speed [$V \propto (M/S)^{1/2}$], and is thus somewhat more significant in evaluating flight characteristics than the relation between mass and wingspan, which has mainly to do with vehicle drag and lateral (roll) control characteristics. The point is that, based on the laws of applied aerodynamics, it seems the bird is a poor model on which to base pterosaur flight characteristics, while the hang glider appears to be a direct counterpart. It should be noted, however, that no current hang glider has gliding performance approaching that estimated for *Pteranodon* (2) (and presumably *Quetzalcoatlus*).

Provided their estimates of meteorological conditions during the Cretaceous are correct, the flight modes of the large pterosaurs deduced by Bramwell and Whitfield are well verified by 5 years of operational experience with several thousand Rogallo wing hang gliders. Two major questions require further clarification, however. (i) How did the large pterosaurs take off if no hill or cliff was available to "leap" from? (ii) What is the maximum feasible size (specifically wingspan and mass) of a device of pterosaur configuration?

Both questions can probably be resolved rather economically by construction of full-sized models, perhaps rigged as a hang glider. On the question of maximum feasible size, it should be noted that the 12-m span Cronk V has poor lateral control characteristics, although it uses a spoiler system for control rather than the pterosaur system of differential sail billow. On the basis of this consideration and the general problem of making very low speed banked turns with "large"-span wings, I tend to favor Lawson's alternative estimate of an 11-m span for *Quetzalcoatlus*.

JOHN H. McMASTERS

School of Aeronautics and
Astronautics, Purdue University,
West Lafayette, Indiana 47907

References

1. C. Bramwell and G. Whitfield, *Philos. Trans. R. Soc. London Ser. B* **267**, 503 (1974).
2. J. H. McMasters, *Soaring* (June 1975), p. 22.
3. C. H. Greenewalt, *Smithson. Misc. Collect.* **144** (No. 2), 1 (1962).
4. J. H. McMasters, *Tech. Soaring* **3** (No. 4), 17 (Fall 1975).

PROFESSIONAL DISCOUNT PRICES AVAILABLE ON



Texas Instruments Engineering Calculators

PHONE TOLL-FREE
800-638-8906

FOR THE CURRENT LOW DISCOUNT PRICE
OF THE LATEST MODEL TEXAS
INSTRUMENTS CALCULATOR OF
YOUR CHOICE

Texas Instruments SR-52



Programming power from Texas Instruments. Easy hand held programming for scientists, engineers, students—anyone who works with advanced mathematics. Check these features: 224 program locations, 20 addressable memory registers, 23 pre-programmed key functions, indirect addressing, permanent program storage on magnetic cards.

Texas Instruments SR-56



More power from Texas Instruments. Hand held key programmable calculator. 100 program steps, 5 program levels (up to 4 levels of subroutine may be defined). Easy single step editing. Main features include 26 preprogrammed key functions, 10 addressable memory registers, algebraic logic and 9 levels of parentheses.

PC-100 Lock down printer; for a hard copy of your results; step by step listing of programs, or "debugging" programs. The PC-100 printer may be used with the SR-56 or SR-52.

OTHER MODELS AVAILABLE

SR-50A, SR-51A, TI 255011, TI 250011, TI 5100

**ALL THE FAMOUS
TEXAS INSTRUMENTS
ELECTRONIC CALCULATORS
ARE AVAILABLE AT DISCOUNT PRICES**

Mail and phone orders accepted. Master Charge and BankAmericard accepted. Add \$2.50 per unit for shipping and handling. Maryland residents add 4% sales tax.

Use our toll free phone: **800-638-8906** (Maryland residents phone: **(301) 340-7200**) to order or for current discount quotations on the leading brands of electronic calculators: Texas Instruments, Hewlett-Packard, Rockwell, Ricoh, Kingspoint, Corvus, Novus, and many more.

THE GUARANTEE

10 day money back trial. If you are not completely satisfied you may return the Texas Instruments calculator you order within 10 days for a cash refund or charge cancellation. In addition Texas Instruments Inc. and Capital Calculator Co. Inc. warrant each calculator for a period of one year against defective parts and workmanship.

Capital Calculator Company



**701 East Gude Drive
Rockville, Maryland 20850**

THE SCIENCE REPORT ON CANCER RESEARCH

SEEDS OF DESTRUCTION

THOMAS H. MAUGH II
AND JEAN L. MARX

American Association for the Advancement of Science

Now, from the pages of *Science*, comes a report on what is really occurring in cancer research. Two investigative reporters, Tom Maugh and Jean Marx, found out from the experts what they think and what they're doing. And it's all down in language easily understood by nonprofessionals. This book—based on months of intensive research, and drawing on hundreds of interviews with leading specialists—gives the answers to such urgent questions as:

- What is cancer?
- How does it kill?
- Do chemicals cause cancer?
- What about viruses?
- Does the body try to fight cancer naturally?
- Can radiation cure some cancers?
- Do drugs work?
- What about leukemia?

The reader tours with the authors through laboratories here and abroad discovering past trends and what's happening right now. For example, they show that scientists who previously sought the cause of cancer in isolated viruses are now searching for ways of detecting traces of viruses within the human tumor itself.

In exciting detail, all the fascinating paths taken by scientists to discover how chemicals interact with cells, whether the body can create its own defense against cancer, and how physicians are trying new ways of treating cancer patients—all this and more is found in this impressive account.

It is a must for anyone who has ever wondered what cancer is and what is being done to find out how it starts and how to cure it.

An ideal text!

Students of cancer and cancer research at every level will welcome **Seeds of Destruction**.

The book presents a clearly stated definition of the etiology of the disease and reviews past and present research and methodology. Benefiting from clear, jargon-free language and thirty illustrations plus twelve tables, the student is fully prepared to carry on his own investigations. This text also provides a glossary of terms which stands as the best available dictionary of cancer terminology.

This highly practical and valuable aid is a "must" on the bookshelf of every student and researcher.

Published in cooperation with the American Association for the Advancement of Science.

\$17.95

PLENUM PUBLISHING CORPORATION
227 West 17th Street, New York, N.Y. 10011

In United Kingdom: 8 Scrubs Lane, Harlesden,
London NW10 6SE, England

Prices subject to change without notice.
Prices slightly higher outside the U.S.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Science serves its readers as a forum for the presentation and discussion of important issues related to the advancement of science, including the presentation of minority or conflicting points of view, rather than by publishing only material on which a consensus has been reached. Accordingly, all articles published in *Science*—including editorials, news and comment, and book reviews—are signed and reflect the individual views of the authors and not official points of view adopted by the AAAS or the institutions with which the authors are affiliated.

Editorial Board

1976

ALFRED E. BROWN	FRANK PRESS
JAMES F. CROW	FRANK W. PUTNAM
HANS LANDSBERG	MAXINE SINGER
EDWARD NEY	ARTHUR M. SQUIRES

1977

WARD GOODENOUGH	DONALD KENNEDY
CLIFFORD GROBSTEIN	NEAL E. MILLER
H. S. GUTOWSKY	RAYMOND H. THOMPSON
N. BRUCE HANNAY	

Editorial Staff

Editor

PHILIP H. ABELSON

Publisher

WILLIAM D. CAREY

Business Manager

HANS NUSSBAUM

Managing Editor: ROBERT V. ORMES

Assistant Editors: ELLEN E. MURPHY, JOHN E. RINGLE

Assistant to the Editors: RICHARD SEMIKLOSE

News and Comment: JOHN WALSH, *Editor*; PHILIP M. BOFFEY, LUTHER J. CARTER, BARBARA J. CULLITON, ROBERT GILLETTE (on sabbatical), CONSTANCE HOLDEN, DEBORAH SHAPLEY, NICHOLAS WADE. *Editorial Assistant*, SCHERRAINE MACK

Research News: ALLEN L. HAMMOND, WILLIAM D. METZ, THOMAS H. MAUGH II, JEAN L. MARX, ARTHUR L. ROBINSON, GINA BARI KOLATA, FANNIE GROOM

Book Reviews: KATHERINE LIVINGSTON, LYNN MANFIELD, JANET KEGG

Cover Editor: GRAYCE FINGER

Editorial Assistants: JOHN BAKER, ISABELLA BOULDIN, MARGARET BURESCH, ELEANORE BUTZ, MARY DORFMAN, SYLVIA EBERHART, JUDITH GIVELBER, CAITILIN GORDON, CORRINE HARRIS, NANCY HARTNAGEL, OLIVER HEATWOLE, CHRISTINE KARLIK, MARGARET LLOYD, JEAN ROCKWOOD, LEAH RYAN, LOIS SCHMITT, YA LI SWIGART, ELEANOR WARNER, ROBERTA WEDGE

Guide to Scientific Instruments: RICHARD SOMMER

Membership Recruitment: GWENDOLYN HUDDLE; *Subscription Records and Member Records:* ANN RAGLAND

Advertising Staff

Director

EARL J. SCHERAGO

Production Manager

MARGARET STERLING

Advertising Sales Manager: RICHARD L. CHARLES

Sales: NEW YORK, N.Y. 10036: Herbert L. Burklund, 11 W. 42 St. (212-PE-6-1858); SCOTCH PLAINS, N.J. 07076: C. Richard Callis, 12 Unami Lane (201-889-4873); CHICAGO, ILL. 60611: Jack Ryan, Room 2107, 919 N. Michigan Ave. (312-DE-7-4973); BEVERLY HILLS, CALIF. 90211: Winn Nance, 11 N. La Cienega Blvd. (213-657-2772); DORSET, VT. 05251: Fred W. Dieffenbach, Kent Hill Rd. (802-867-5581)

EDITORIAL CORRESPONDENCE: 1515 Massachusetts Ave., NW, Washington, D.C. 20005. Phones: (Area code 202) Central Office: 467-4350; Book Reviews: 467-4367; Business Office: 467-4411; Circulation: 467-4417; Guide to Scientific Instruments: 467-4480; News and Comment: 467-4430; Reprints and Permissions: 467-4483; Research News: 467-4321; Reviewing: 467-4443. Cable: Advancesci, Washington. Copies of "Instructions for Contributors" can be obtained from the editorial office. See also page xi, *Science*, 26 September 1975. ADVERTISING CORRESPONDENCE: Room 1740, 11 W. 42 St., New York, N.Y. 10036. Phone: 212-PE-6-1858.

A Global Rush Toward Nuclear Energy

Perhaps the most important sequel to the Arab oil embargo has been movement toward widespread adoption of nuclear energy. Some 38 countries outside the United States have a total of 260 power reactors either operating, under construction, or on order. Although the United States still has a major role in nuclear matters, it is rapidly losing its technological and political supremacy.

The situation is complex; one approach toward insight is to concentrate on a single country—France. This nation has little indigenous coal and oil. In 1950 its energy consumption was the equivalent of 87.5 million metric tons of coal (MTec), 65.3 million coming from coal and 15.5 million from oil. By 1973 energy use had tripled, but consumption of coal had fallen by a third while use of petroleum had increased more than 11-fold to 175.6 MTec. Thus, France had become dependent on oil imports for about two-thirds of its energy. In contrast, the United States obtains about 14 percent of its energy from foreign sources. If there is need for the United States to attain energy independence, there is desperate need for France to do so.

The French, who have abundant domestic reserves of uranium, have chosen to place emphasis on nuclear energy, in which they have developed considerable expertise. Their first research reactor went critical in 1948 and the first power reactor in 1958. (Later they obtained extensive know-how from Westinghouse and General Electric.) They have in operation a small gaseous diffusion plant for separation of uranium isotopes and nuclear fuel processing plants to produce plutonium, and they are well along with techniques for handling radioactive waste. They have now had nearly two years' successful experience with a 250 Mwe breeder reactor and in this respect are far ahead of their U.S. counterparts.

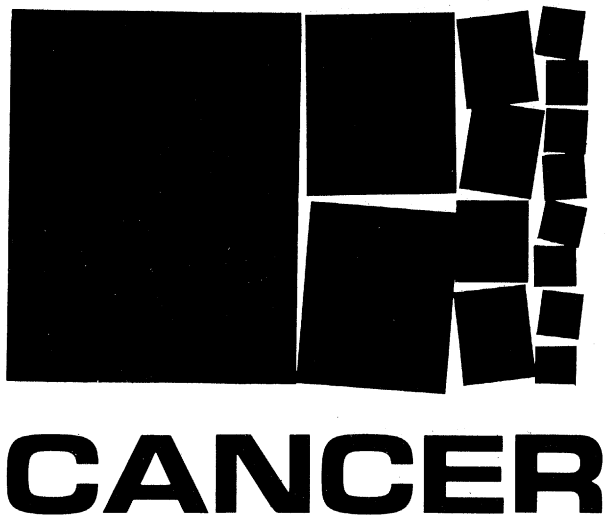
Before the embargo, France was obtaining 8.5 percent of its electricity from nuclear reactors. The plan for 1985 calls for 72 percent nuclear, 14 percent hydroelectric, and 14 percent thermal power, with almost all of the latter coming from domestic coal. France is likely to reach these goals. The time required for planning and constructing a power reactor there is about half that in the United States.

France is also a major participant in an international consortium which is building a very large isotope separation plant to produce enriched uranium for power reactors. The partners include groups from Belgium, Italy, Spain, and Iran. The plant is scheduled to begin operation in 1979 and reach full production in 1981. It will have an annual production capacity of 10.8 million separative work units (SWU), or 2670 metric tons of enriched uranium having an assay of 3.15 percent ²³⁵U. A second large plant is in the planning stages with construction dependent on obtaining orders for nuclear fuel. Present U.S. capacity, which is being upgraded, is 16.6 million SWU.

In addition to the consortium, others, including an English-Dutch-German combine and the Russians, are producing and selling enriched uranium for reactors. The virtual monopoly of the United States is about to end. There has been talk on Capitol Hill of shutting off exports of enriched uranium, but this would merely lead to expediting the construction of separation plants elsewhere and to a further loss of U.S. influence.

The oil embargo forcefully reminded many nations that oil reserves are limited and oil supplies are vulnerable to other interruptions. The quadrupling of the price of oil made nuclear energy look very attractive from the viewpoints of cost and balance of payments. The embargo also came at a time when a number of industrialized countries had accumulated some experience in the design, construction, and operation of nuclear power reactors.

A country possessing power reactors is a step along the way toward nuclear weapons. However, irradiated fuel that contains plutonium also contains tremendous quantities of fission-product radioactivity. To obtain weapons-grade plutonium requires a complex processing plant. The best hope for holding down weapons proliferation is to bring spent-fuel processing plants under international control. Attaining such an objective should be a major and urgent goal of U.S. foreign policy.—PHILIP H. ABELSON



Who knows about it?

No one expert knows all its complexities.

But many experts know many different aspects.

You have to bring the experts together to get the whole story.

AAAS has brought together 19 recognized authorities in a new audiotape album—CANCER. Interviewed by two science journalists, these experts talk about:

- The psychological impact of cancer on patients, families, physicians and the public.
- Facts and fallacies about cancer's warning signals.
- Crucial factors in diagnosis.
- New progress in tailor-made therapy.
- Why the statistics are so grim.
- Where basic research is leading.

These and many more cancer topics are covered in four one-hour cassettes. Each attractively-bound, book-style album also contains a 40-page booklet which summarizes the tape-recorded interviews.

To hear what medical science knows about cancer and the directions it is taking toward new knowledge, order your CANCER audiotape album now. Or, order a copy of the CANCER booklet alone.

ORDER FORM

CANCER AUDIOTAPE ALBUM

- ☐ \$49.95 Retail
☐ \$44.95 AAAS members
☐ Check enclosed (Payable to AAAS)
Prepaid orders are postpaid in the U.S.

CANCER BOOKLET

- ☐ \$2.50 Retail
☐ \$2.00 AAAS members
☐ Bill me (\$2 handling charge)

Please send me _____ CANCER audiotape album(s) (includes booklet) for _____ each

Please send me _____ CANCER booklet(s) (without album) for _____ per copy

Name: _____

Address/Box No.: _____

City, State, Zip: _____

Mail to:



American Association for the Advancement of Science

Dept. C., 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005