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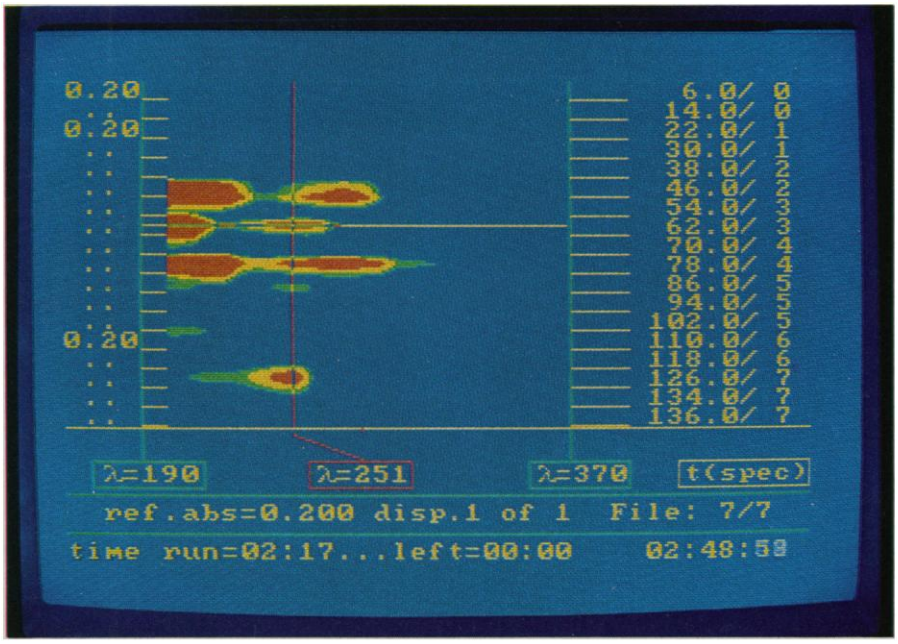


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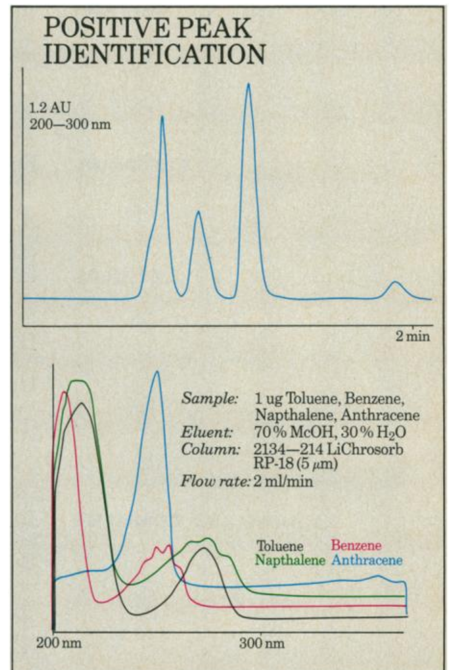


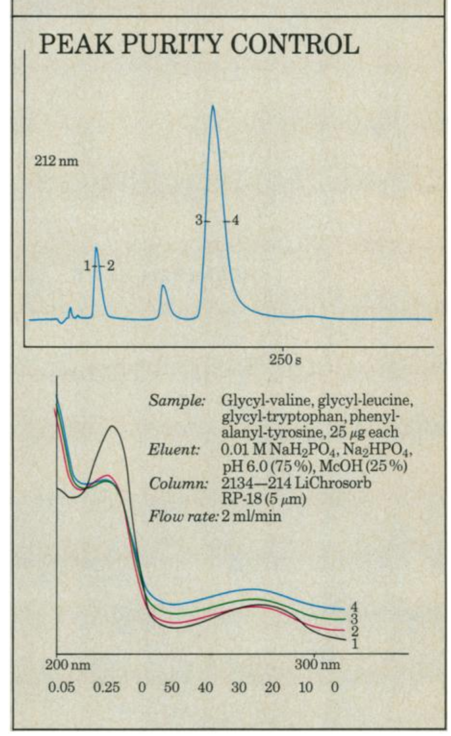


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# SCIENCE





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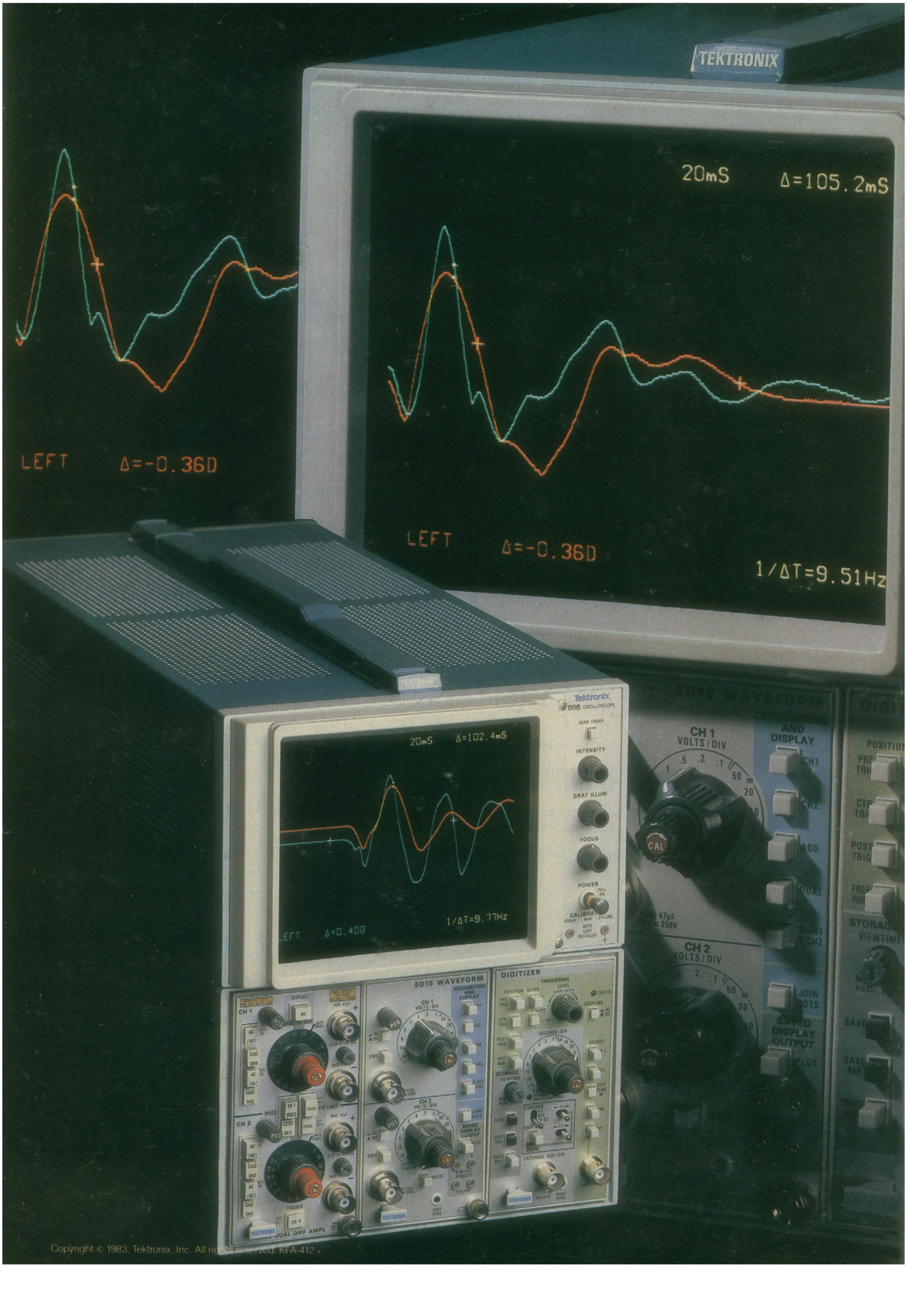
**COVER**

Synchronous spawning by polyps of a staghorn coral, *Acropora listeri*. The oral discs of the polyps bulge with apricot-colored egg-sperm bundles in readiness for release. The bundles float to the surface and break apart; subsequent external fertilization leads to development of planula larvae. See page 1186. [Peter Harrison, James Cook University of North Queensland, Australia]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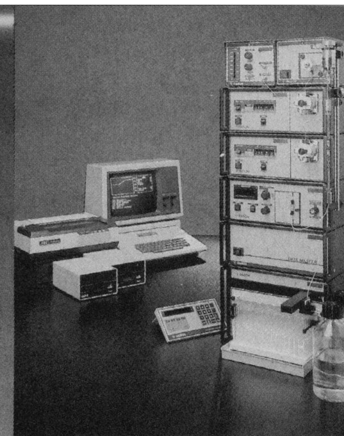

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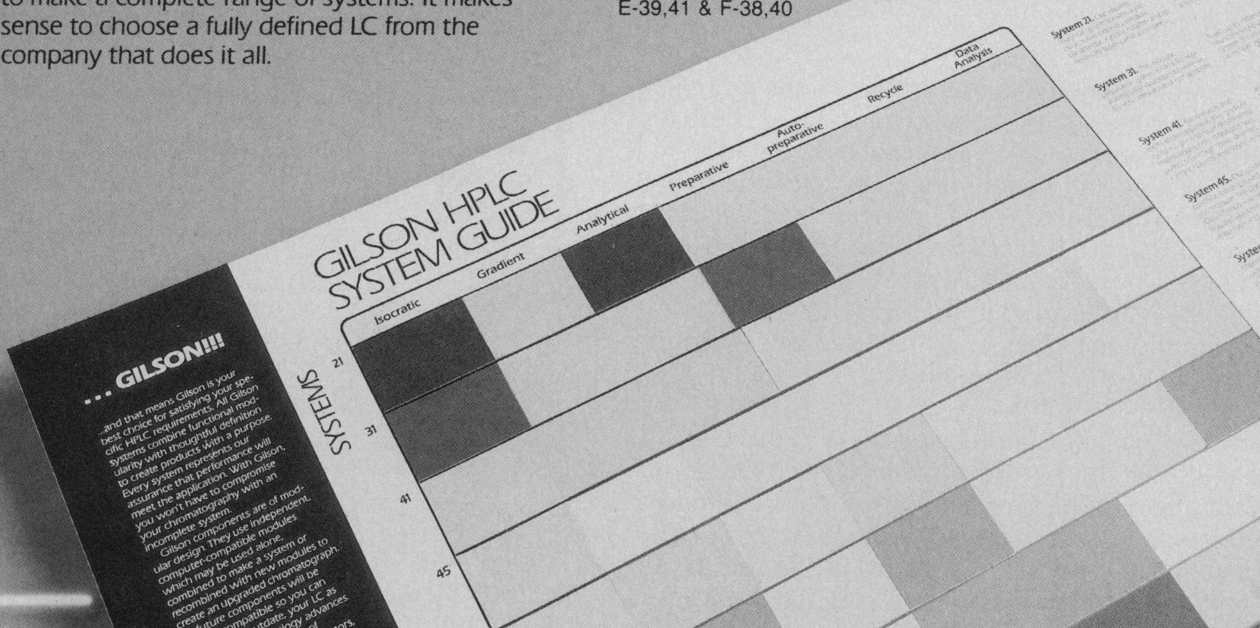


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**LETTERS**

## Giant Panda Paternity

We have determined by biochemical genetic procedures that the baby giant panda (*Ailuropoda melanoleuca*) born at the National Zoological Park in July 1983 was the offspring of the Washington male (Hsing-Hsing) and have excluded the possible parentage by the London male, Chia-Chia. The question arose because the mother, Ling-Ling, successfully mated with Hsing-Hsing (for the first time!) in March 1983 and was artificially inseminated with sperm from Chia-Chia on the 2 days following the sexual encounter.

Ling-Ling first showed signs of sexual receptivity in the spring of 1973 and has demonstrated estrus once a year ever since. Although Hsing-Hsing is a rather healthy male, his sexual encounters with Ling-Ling through the 1970's were unsuccessful due to what has been politely termed an orientation problem (*1*).

In 1980, artificial insemination was attempted on 2 days of estrus using fresh spermatozoa collected from Hsing-Hsing by electroejaculation (*2*), but no pregnancy resulted. In 1981, the London male giant panda, Chia-Chia, was flown to Washington for a mating encounter with Ling-Ling. This pairing resulted in an aggressive and extended physical attack on Ling-Ling by Chia-Chia, which did not include copulation. In 1982, Ling-Ling was again artificially inseminated on each of 3 days of estrus. Frozen-thawed spermatozoa from Chia-Chia were used on the first day, and fresh spermatozoa from Hsing-Hsing were used on the second and third days. During this estrus Ling-Ling was subjected to two laparoscopic examinations at 48-hour intervals so that ovarian activity could be evaluated. Although the reproductive organs appeared morphologically normal and follicular luteinization was detected, the artificial insemination was not successful in producing a panda cub.

On 17 March 1983, Ling-Ling displayed symptoms of estrus again; on 18 March, Hsing-Hsing successfully mounted and copulated. On 19 and 20 March, fresh buffered spermatozoa was collected at the London Zoo from Chia-Chia and the specimens were used for artificial insemination. On 21 July, Ling-Ling gave birth to a male cub weighing 134 grams. Approximately 3 hours after birth, the cub died. Eleven hours later, the cub was removed from the cage, an autopsy was performed, and the cause of death was determined to be acute pneumonia that had developed prenatally from an ascending *Pseudomonas* infection in the birth canal.

In order to establish paternity for the baby panda, a blood sample and a skin biopsy were obtained on 21 July and the skin was placed in tissue culture at the National Institutes of Health. Blood and skin biopsies from Ling-Ling, Hsing-Hsing, and Chia-Chia were also collected and placed in cell culture. As there is nothing known of biochemical genetic variation in this species, we used two techniques to detect informative polymorphic gene products. The first was to sample 29 isozyme loci, 22 of which we have designated as mammalian "polymorphic cluster" enzyme loci because they tend to be polymorphic in other mammalian species (*3*). They were ACP1, ACP2, ADA, ESA, ESD, FUCA, GALA, GALB, GOT1, GOT2, G6PD, GPI, GSR, GLO, HK1, HK2, IDH1, MDH1, ME1, PEPA, PEPB, PEPC, PEPD, PGD, PGM1, PGM3, PP, SOD1, and MPI (*4*). Surprisingly, none were polymorphic in our group of four giant pandas.

The second approach consisted of the separation at high resolution of abundant soluble proteins in two dimensions (2DE) on polyacrylamide gels (*5*). Proteins from the four cell lines (from baby, Ling-Ling, and the two suspect fathers) were labeled with $^{14}C$ amino acids and subjected to 2DE gels and autoradiography plus silver staining for detection of proteins. The autoradiographic patterns were analyzed by computer-assisted densitometry (*6*). Of the approximately 300 proteins examined, six exhibited quantitative polymorphism within the sample of four. Each polymorphism involved a mobility shift due to charge alteration, and all the putative polymorphisms exhibited gene dosage dependence in heterozygotes which is consistent with a genetic basis (*5*). The phenotypes of the four animals at each of the six loci, designated p90, p68, and so forth, after their molecular weights ($\times 10^{-3}$) appear in Table 1. Two of the loci, p90 and p73, show that the only way that the baby could have been Ling-

Table 1. Panda phenotypes. Abbreviations: A, acidic allele homozygote; B, basic allele homozygote; and AB, heterozygote.

| Protein | Ling-Ling | Baby | Hsing-Hsing | Chia-Chia |
|---|---|---|---|---|
| p90* | A | AB | AB | A |
| p68 | AB | B | B | B |
| p32 | AB | AB | B | B |
| p73* | B | AB | AB | B |
| p112 | AB | AB | A | AB |
| p54 | A | A | A | AB |

*Informative loci.

# SCIENCE/SCOPE

In a step toward faster and more powerful integrated circuits, a Hughes Aircraft Company research team has made submicrometer transistors using focused ion beam lithography. The group made N-channel silicon MOSFETs with self-aligned submicrometer polysilicon gates. The smallest dimension of the gates ranged from 0.35 to 1.2 micrometers. The focused ion beam was used to expose a highly sensitive resist, which provided a mask for reactive ion etching the polysilicon by a combination of chlorine and fluorine-based etch gases. Outstanding electrical performance was obtained for the N-channel FETs, which employed a 100-angstrom-thick gate oxide.

F-15 Eagle pilots use the latest computer technology to manage advanced systems in their skyborne offices. Improvements give the F-15's unique "look-down shoot-down" radar 10 times the memory of a 48K personal computer. The F-15's central computer and armament control system will be enhanced by increasing storage and reducing pilot workload. Under the multistaged improvement program (MSIP), the radar's memory eventually will increase to 1 million words and its processing speed will triple to 1.4 million operations per second. The resulting radar will have fewer parts and increased reliability. Hughes builds the F-15's AN/APG-63 radar under contract to McDonnell Douglas for the U.S. Air Force.

An optical fiber that survives baking, stretching, and radiation promises to find many important military uses. The aluminum-coated fiber, developed by Hughes research scientists, was subjected to severe environmental testing. It withstood temperatures up to 400°C, high strain (2%) at temperatures to 400°C, and a heavy (1 megarad) dose of cobalt radiation. Ordinary plastic-coated fibers would have melted, snapped, and lost their ability to transmit light. The metal-coated fibers will replace electrical wiring in many avionic and seaborne systems.

Six gallium arsenide field-effect transistors, designed for power amplifiers in radar and communications applications, have been introduced by Hughes. The single- and dual-cell power transistor chips are mounted on internally matched chip carriers. The devices consist of 10-GHz, 13-GHz, and 15-GHz power FETs capable of output power levels up to 1.5 watts. They are matched to operate in a 50-ohm-in/50-ohm-out system for a full 2-GHz bandwidth.

Hughes needs engineers, scientists, and programmers to design and build advanced airborne and spaceborne radar systems, including data links, electronic warfare systems, and display systems. We need systems analysts (communications and control theory, signal processing, applied mathematics), microwave specialists (antenna, receivers, transmitters, data processors), circuit designers (analog, digital, RF/IF), scientific programmers, mechanical designers, systems and test engineers. Send resume to Engineering Employment, Dept. S2, Hughes Radar Systems Group, P.O. Box 92426, Los Angeles, CA 90009. Equal opportunity employer.

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Ling's son is if Hsing-Hsing had been the father. Chia-Chia is excluded by both loci. The genotypes of the four other loci are also consistent with this explanation.

These results are reassuring insofar as they confirm the virility and fertility of Hsing-Hsing and add another breeding male to the very small population of captive male giant pandas.

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4. Abbreviations are as follows: ACP1, erythrocyte acid phosphatase; ACP2, tissue acid phosphatase; ADA, adenosine deaminase; ESA, esterase-A; ESD, esterase-D; FUCA, α-L-fucosidase; GALA, galactosidase-A; GALB, galactose-B; GOT1, glutamate oxaloacetate transaminase-1; GOT2, glutamate oxaloacetate transaminase-2; G6PD, glucose-6-phosphate dehydrogenase; GPI, glucose phosphate isomerase; GSR, glutathione reductase; GLO, glyoxalase-1; HK1, hexokinase-1; HK2, hexokinase-2; IDH1, isocitrate dehydrogenase-1 (soluble); MDH1, malate dehydrogenase-1 (soluble); ME1, malic enzyme 1 (soluble); PEPA, peptidase-A; PEPB, peptidase-B; PEPC, peptidase-C; PEPD, peptidase-D; PGD, 6-phosphogluconate dehydrogenase; PGM1, phosphoglucomutase-1; PGM3, phosphoglucomutase-3; PP, pyrophosphatase, inorganic; SOD1, superoxide dismutase-1; and MPI, mannose phosphate isomerase.
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7. Copies of gel photographs are available by request from the authors. The excellent technical assistance of Mary Eichelberger and Janice Martenson is gratefully acknowledged.

## Ediacaran Fossils

In his article "Alien beings here on Earth" (Research News, 6 Jan., p. 39), Roger Lewin reports on the views of Adolf Seilacher of Tübingen University with respect to fossils occurring in the Late Precambrian Ediacaran beds of South Australia. Seilacher is said to believe that these fossils have a completely different architecture and physiology from Phanerozoic (Cambrian-Recent) organisms. It is reported to be his view that these body fossil organisms of some 670 million years ago died without descendants.

Many of the Ediacaran body fossils have already been described and attributed without exception to extant phyla of marine organisms but, according to Seilacher, one can question these attributions for two reasons. He says that the Ediacaran sediments are coarser than those which, in the Phanerozoic, contain preserved evidence of the groups involved. This is especially so in the case of soft-bodied organisms, as most of the described Ediacaran fauna are. He thinks the Proterozoic organisms were invested with a tougher integument than later organisms (and hence were better preserved in coarse sediments) and had primordial flattish and "quilted" surface, elsewhere unknown. Because he found no evidence of a mouth in some of the organisms heretofore attributed to Vermes, Seilacher concludes they were mouthless (and presumably gutless) and that their seeming metamerism is an illusion; he speculates that they were possibly acellular and carried on their physiologic processes directly by transfusion through their thick integumental wall. It should be pointed out, however, that it is unusual indeed to find the mouth area preserved in rare fossil worms which, by their segmented nature, invite disassociation after death; and pray how, other than flattened, would one expect to find a worm preserved? Or any other essentially soft-bodied creature?

Mine is the traditional view that the Ediacaran fauna is a backward projection of the Cambrian shallow benthos requiring no exceptional explanations of any sort. In the more than 130 million years between the Ediacaran time and the earliest Cambrian, hard parts (calcium phosphate, calcium carbonate, chitin), which may have been incipient in the Ediacaran organisms, were widely developed by invertebrate creatures. This made their basal Phanerozoic preservation not only abundant, but so much so by way of contrast as to seem to some paleontologists to have been the result of essentially instantaneous "explosive" evolution. In contrast to Seilacher's attribution of the known Ediacaran fauna to a "world apart," most of it seems to me to fit comfortably into extant phyla.

In the earliest Cambrian, many of the organisms seem to have been at that time "living fossils" which necessarily had had a long antecedent, but undiscovered, evolutionary history. Current work on primitive arthropods (trilobites and non-trilobites) furnishes considerable evidence of this nature. The presence also in the Early Cambrian of the remains of several higher arthropod lineages, some

of which became extinct in the Phanerozoic, others of which are extant, also indicates a long antecedent evolutionary history before their first appearances as fossils. The same kind of evidence exists for the early Echinodermata.

When one considers the vastness of Precambrian time, during which life existed in oceanic waters, and the undoubtedly gradual change of the nature of those waters, it would be indeed strange if there were not a multitude of these ancients yet to be discovered as fossils; moreover, it would be surprising if some of these lineages were not unique to the Precambrian; thus an open mind is required in testing the oldest organisms with respect to their relevancy to the Phanerozoic biota. But arguments for such novelties should be well grounded.

We can only wish Seilacher success in his further study of the Ediacaran trace fossils and hope that this will encourage others to undertake similar studies of Precambrian deposits for organic remains. Such quests are of immense importance to an understanding of organic evolution.

KENNETH E. CASTER
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Caster misses the point when he seeks to imply that Seilacher is unaware that when soft-bodied marine organisms are fossilized they are typically flattened. What is of interest is that the evident quilted structure of many of the Ediacaran fauna indicates that these organisms were also of a generally flattened appearance in life. Hence, at least in part, Seilacher's inference of the unusual diffusional mode of nutrient and metabolite transport.—ROGER LEWIN

## Acetylene on Titan

The ocean of ethane on Titan proposed by Lunine, Stevenson, and Yung (Reports, 16 Dec., p. 1229) is a fascinating idea to an organic chemist, but the suggested layer of solid acetylene ($C_2H_2$) 100 to 200 meters thick lining the bottom is utterly fantastic. "Don't liquefy acetylene, but whatever you do, don't freeze it!" is the advice I remember from my days at E. I. du Pont. The legendary explosive character of the liquid or solid is attested in the older literature (*1*). The unfavorable heat of formation from the elements, 227 kilojoules per mole, is more than twice the energy of explosion of an equal weight of TNT (*2*). Thus, the estimated instability of Titan is approximately 200 to 400 megatons per square kilometer of the planet's surface (*3*). Fantasies of the first space probe's triggering a spectacular detonation of the whole planet are dampened by the knowledge that meteorites have been there first, and prosaic chemical reactions such as polymerization probably never allowed the explosive solid to accumulate in the first place.

DONALD S. MATTESON
*Department of Chemistry, Washington State University, Pullman 99164-4630*

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2. *International Critical Tables*, E. W. Washburn, Ed. (McGraw-Hill, New York, 1929), vol. 5, p. 181; *ibid.*, vol. 7, p. 490.
3. A megaton of TNT occupies a cube approximately 100 meters on a side.

We acknowledge the rather explosive properties of pure, solid acetylene, as noted by Matteson. However, we envision the composition of the solid material underlying the ethane-methane ocean to be considerably more complicated than pure acetylene, as we suggest briefly in our report. The dissociation of methane and consequent production of hydrocarbons in the Titan stratosphere from methane must produce not only $C_2$ and $C_3$ hydrocarbons but also much heavier long-chain polymers (incorporating nitrogen), at the expense, in part, of acetylene (*1*). This material has been inferred by a number of authors (*2*) to be the source of haze layers visible in Voyager images. The base of the ocean must therefore be a collection of complex polymers, solid acetylene, and intermediate photochemical products stable as solids under the ambient conditions. The final proportions of the various products after descent through the atmosphere and the intimacy of the mixture on the ocean floor are at present difficult to quantify but of interest, since the presence of impurities can slow further polymerization of acetylene. The possibility of meteorite impacts inducing further reactions of hydrocarbons both *in* the ocean and at its base is a fascinating one; the frequency of impacts by objects sufficiently large to reach the ocean and affect the base is $10^7$ to $10^8$ years.

JONATHAN I. LUNINE
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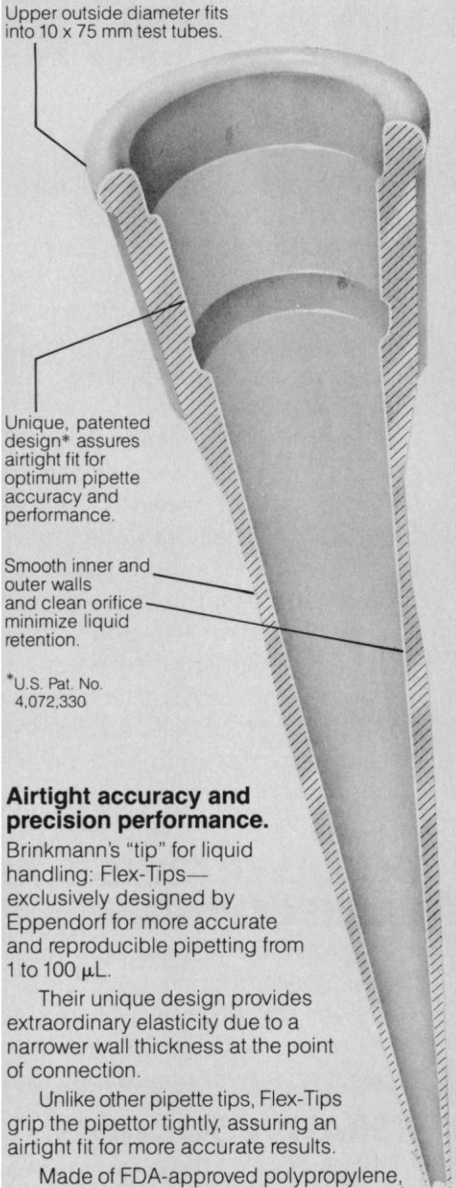

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# SCIENCE



## Federal R & D Budget: Guns Versus Butter

U.S. scientists and engineers are generally aware that federal funding for R & D for the military has increased sharply in recent years. What is less appreciated is that federal funding for the rest of the nation's R & D effort has considerably decreased. Using words from a classic phrase, R & D funding for "guns" is up and R & D funding for "butter" is down.

The National Science Foundation compilation* of federal R & D funding for fiscal years 1980 through 1984 by budget function, corrected for inflation with official deflators (fiscal 1984 is set at 100), reveals the following in billions of constant dollars.

| Category | Fiscal year budget | | | | | Increase 1980–1984 (%) |
|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | 1984 | |
| Total R & D | $39.0 | $39.2 | $39.6 | $40.4 | $45.7 | 17 |
| National defense | $19.4 | $21.7 | $24.2 | $26.2 | $32.0 | 65 |
| All other R & D | $19.6 | $17.5 | $15.4 | $14.2 | $13.7 | −30 |

Figures for fiscal 1983 and 1984 are estimates. However, the opposite trends of support are obvious. NSF lists 15 nondefense budget functions that obtain federal support for R & D. Of these, only one, general science, which is primarily basic research, shows an increase in constant dollars between fiscal 1980 and 1984; the 4-year increase is a modest 7 percent. In President Reagan's recent budget proposals for R & D for fiscal 1985, the dominance of funding for the military continues.

The rapid increase in R & D for the military is not surprising; it was almost inevitable, given the large expansion of military budgets. The surprise is the magnitude of the decrease in support of nondefense R & D. This has occurred in the face of rising concern about the international competitiveness of our industries and the need for increasingly innovative U.S. technology. One response to these concerns was passage of the Economic Recovery Tax Act of 1981, which provided U.S. industry with a 25 percent annual tax credit for incremental R & D expenditures. Partly as a result, industry funding of R & D rose between 1980 and 1984 at about 6 percent per year in constant dollars.

There are fields of effort where contributions by industry are small or fragmented and where federal support of R & D is essential. These include health (other than drugs), energy, housing, agriculture, environmental protection, and natural resources. Basic research, which supplies the fundamental knowledge on which industrial R & D builds, also requires federal support, since industry's contribution is slight.

Will the pressure for increased military R & D ease soon? The answer is almost surely no, since large increases in budgets for the military are proposed for the next several years, and there is no reason to expect the fraction for R & D to decrease. The most likely future is intensified pressure on all other federal budgets, including those for R & D. What then is to be done to obtain more adequate federal support for civilian R & D? Three efforts suggest themselves: develop more persuasive arguments to federal agencies and Congress on the need for more support for R & D in nonmilitary areas; emphasize the need for more basic research, particularly in areas that supply the scientific base for our industries; and urge greater effectiveness in the federal government's civilian R & D support programs, with less emphasis on such research spectaculars as the Manned Space Laboratory and tighter constraints on the burgeoning expenditures for military R & D.

Scientists and engineers have a particular responsibility to understand these problems and make their recommendations known. What is at stake is the future prosperity of our nation.—F. A. LONG, *Program on Science, Technology, and Society, Cornell University, Ithaca, New York 14853*

**Science Resources Studies Highlights, NSF 83-323*, 14 October 1983.

**16. New York Botanic Garden.** Monday, 28 May, 12:30 p.m.–4:30 p.m. (Limit: 30 persons)

Visit the Enid A. Haupt Conservatory, an acre of gardens under glass, containing 11 galleries and pavilions, each with a different plant environment. See also the Rose, Systematic, Chemurgic, and Herb Gardens and other exhibits.

**17. Subway Safari: NBC and Rockefeller Center.** Monday, 28 May, 12:30 p.m.–4:30 p.m. (Limit: 30 persons)

Led by professional guides, this tour will take you to the NBC TV studios and the famous Rockefeller Center.

**18. Broadway Musical: *Cats*.** Monday, 28 May; Showtime: 8:00 p.m. (Limit: 48 persons)

This award-winning show is the most exciting musical on Broadway today! AAAS will send you a voucher; pick up your tickets at the AAAS Ticket Desk.

**19. AT&T Bell Laboratories.** Tuesday, 29 May, 8:30 a.m.–1:00 p.m. (Limit: 100 persons)

The facility is located in Murray Hill, New Jersey, 1-hour's drive from midtown Manhattan. Here, at the birthplace of the transistor, advanced research and development is performed across a broad range of scientific and engineering disciplines important to information technology. After an introductory presentation, small groups will visit selected laboratories and see current work on very large scale integrated (VLSI) circuits, fiber optics, and recent developments in computer science research.

**20. Subway Safari: Radio City Music Hall and St. Patrick's Cathedral.** Tuesday, 29 May, 9:00 a.m.–1:00 p.m. (Limit: 30 persons)

Our final safari will take you to the majestic beauty of St. Patrick's Cathedral and the wonder of Radio City Music Hall—a great way to end a stay in New York City.

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# Order Form for Tour and Show Tickets

**Name** ____________________

**Institution or Company** ____________________
(If part of mailing address)

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**For tours 1, 10, and 19 indicate citizenship:** ____________________

**Indicate any special requirements due to a handicap:** ____________________

| Tour No. | | Ticket Price | No. of Tickets |
|---|---|---|---|
| 1. | IBM Thomas J. Watson Research Center (25 May) | $ 7.00 | ____ |
| 2. | Brooklyn Bridge/City Hall (25 May) | 3.00 | ____ |
| 3. | Brooklyn Museum/Botanical Gardens (25 May) | 11.00 | ____ |
| 4. | New York Stock Exchange (25 May) | 2.00 | ____ |
| 5. | David Letterman Show (25 May) | 2.00 | ____ |
| 6. | *Intrepid* Museum (26 May) | 7.00 | ____ |
| 7. | American Museum of Natural History/Hayden Planetarium (26 May) | 9.00 | ____ |
| 8. | Bird Walk in Central Park (27 May) | Free | ____ |
| 9. | South Street Seaport (27 May) | 2.00 | ____ |
| 10. | West Point/Hudson River Boat and Bus Tour (27 May) | 14.00 | ____ |

| Tour No. | | Ticket Price | No. of Tickets |
|---|---|---|---|
| 11. | American Museum of Natural History/Hayden Planetarium (27 May) | $ 9.00 | ____ |
| 12. | Broadway Musical: *42nd Street* (27 May) | 20.00 | ____ |
| 13. | Chinatown/Little Italy (27 May) | 15.00 | ____ |
| 14. | Lower East Side (28 May) | 2.00 | ____ |
| 15. | Soho (28 May) | 3.00 | ____ |
| 16. | New York Botanic Garden (28 May) | 6.00 | ____ |
| 17. | NBC/Rockefeller Center (28 May) | 6.00 | ____ |
| 18. | Broadway Musical: *Cats* (28 May) | 30.00 | ____ |
| 19. | AT&T Bell Laboratories (29 May) | 7.00 | ____ |
| 20. | Radio City Music Hall/St. Patrick's Cathedral (29 May) | 6.00 | ____ |

**Charge to my ☐ VISA or ☐ MASTERCARD. Enclosed is my check ☐**

**Total amount enclosed or charged: $** __________

**Total number of tickets ordered: $** __________

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