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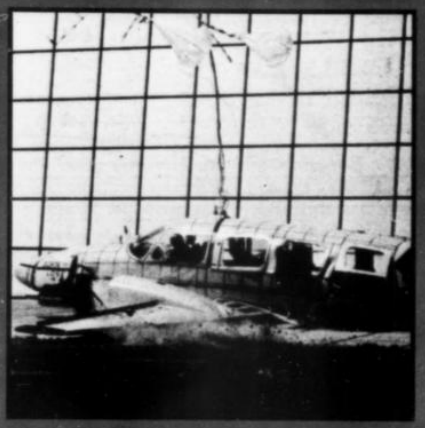


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**ARCHAEOLOGICAL DECIPHERMENT:** A Handbook—E. J. W. Barber—Princeton U Pr, 1974, illus., glossary, $15. Written for the archaeologist faced with some undeciphered texts. Discauses relevant aspects of archaeology, linguistics and computer aids.

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**EXPLORING THE REEF**—Robert P. L. Straughan—A S Barnes, 1974, 9x12, rev. ed., 298 p., color plates, 300 photographs by author, $17.50. Introduces the reader to that underwater oasis teaming with a multitude of creatures and coral, as seen by the deep-sea photographer.

**FACING STARVATION:** Norman Borlaug and the Fight Against Hunger—Leonard Bicket—Readers Digest Pr (Dutton), 1974, 376 p., $8.95. Biography of the Nobel Peace Prize winner whose research made possible the Green Revolution.

**FOCAL POINTS:** A Global Strategy—George Borgstrom—Macmillan, 1973, 320 p., diagrams, maps, tables, $8.95. Leading international authority on food utilization and world nutrition focuses attention on the world's high-pressure regions, on the food-producing potential of certain areas, and concludes with outlining the main elements of a coordinated global program.

**FOR EVERYONE A GARDEN**—Moshe Safdie, Judith Wolin, Ed.—MIT Pr, 345 p., 170 photographs, drawings, $25. Illustrates and discusses such pioneering architectural projects as the three-dimensional community, habitats, resort clusters on lake sites, hillside cluster houses, habitat infrastructure, climate control, and planning a factory.

**THE GENETIC BASIS OF EVOLUTIONARY CHANGE**—R. C. Lewontin—Columbia U Pr, 1974, 346 p., illus., $12.50; paper, $4.50. Expanded lectures on the nature of genetic diversity among organisms, the struggle to measure variation, the genetics of species formation, the paradox of variation, and the genome as unit of selection.

**THE GREAT BARRIER REEF**—Isobel Bennett—Scribner, 1974, 10x12, 183 p., color plates, photographs by author, maps, $17.50. A marine biologist's handsome and comprehensive presentation of Australian marine life and the ecology of the Great Barrier Reef zone.

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**THE HEART** by 18 Authors—Jesse E. Edwards, Maurice Lev, and Murray R. Abell, Eds.—Williams & Wilkins, 1974, 368 p., illus., tables, $21.50. Pathologic studies concern advances in a variety of specific subjects dealing with acquired diseases of the circulatory system and cardiovascular malformations.

**HUNTING FOR FOSSILS:** A Guide to Finding & Collecting Fossils in All Fifty States—Marian Murray—Collier Bks. (Macmillan), 1974, 348 p., illus., paper, $2.95. Reprint (1967), informative guide for the serious amateur.

**IDEAS OF THE THEORY OF RELATIVITY:** General Implications from Physics to Problems of Society—Mendel Sachs—IUP (Halsted Pr), 1974, 190 p., $9.95. Monograph discusses how a single axiom, the principle of relativity, can lead logically to a theoretical structure of tremendous predictive capacity, verified by observations ranging from the microscopic range of particle physics to cosmological intergalactic distances.

**INSTALLING TV & FM ANTENNAS**—Leo G. Sands—TAB Bks, 1974, 168 p., 158 illus., $7.95; paper, $3.95. Practical guide for the home handyman and the neophyte technician who wants to know how to select and install antennas.

**INTO THE OCEAN WORLD:** The Biology of the Sea—Ritchie Ward—Knopf, 1974, 348 p., 50 photographs, illus., $10. Introduces the layman to the scientific world of the great marine biologists, tells of their explorations and the important discoveries they made.

**ISLAND BIOLOGY**—Sherwin Carlquist—Columbia U Pr, 1974, 670 p., photographs, drawings, $25. Comprehensive investigation of the ecological adaptation and morphological diversification of insular flora and fauna, deals with long-distance dispersal, adaptive radiation, insular woodiness, and loss of dispersibility.

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**MUSHROOM POCKET FIELD GUIDE**—Howard E. Bigelow—Macmillan, 1974, 126 p., 64 color plates, pictorial glossary, $3.50. Authoritative concise guide clearly identifying edible, poisonous and questionable mushrooms in woodland and meadow.

**THE NATIONAL FACULTY DIRECTORY 1974**, Vols. 1: A-LANCZ, Vol. 2: LANDS-Z—Gale, 1974, 2,078 p., $85.00. An alphabetical list with addresses of about 400,000 faculty members at junior colleges, colleges and universities in the United States.

**THE NEW SEX THERAPY:** Active Treatment of Sexual Dysfunctions—Helen Singer Kaplan, M.D.—Brunner/Mazel, 1974, 560 p., illus., $17.50. Comprehensive volume covers the anatomy and physiology of the sexual response, the role of hormones and the brain, the biological and psychological causes of sexual dysfuction, and principles and procedures of sex therapy.

**THE NEXT TEN THOUSAND YEARS:** A Vision of Man's Future in the Universe—Adrain Berry, introd. by Robert Jastrow—Sat Rev Pr, 1974, 250 p., $8.95. A highly speculative forecast of possible developments in science and technology, many based on ideas, theories and developments that did not exist a decade or so ago.

**PULMONARY REACTIONS TO ORGANIC MATERIALS**—Kaye H. Kilburn, Ed.—NY Acad. of Sci, Annals, Vol. 221, 1974, 390 p., illus., paper, $28. Papers deal with assessing specific cases and occupational groups, the chemical nature of agents and airway response, defenses of the distal lung, and acute and chronic inflammation.

**THE SATURDAY MORNING GARDENER:** A Guide to Once-a-Week Maintenance—Donald Wyman—Macmillan, 1974, rev. ed., 400 p., illus., map, tables, $7.95; paper, $2.95. To give the home gardener time to enjoy his garden, horticulturist discusses lay-out, shortcuts and aids to maintenance, and lists 900 low-maintenance plants for every location and purpose.

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**VIDEO TAPE RECORDERS**—Harry Kybett—Sams, 1974, 352 p., illus., paper, $8.95. A basic text about the helical vtr's, from fundamentals to numerous examples of electronic circuits and mechanical systems in currently available machines.

**THE WANKEL ROTARY ENGINE:** Introduction and Guide—Harris Edward Dark—Indiana U Pr, 1974, 145 p., illus., $6.95. Describes how the rotary differs from the piston engine, the development of Wankel's rotary, the improvements made by Mazda, and the steps taken by the U.S. automotive industry.

**WHO'S WHO IN CONSULTING:** A Reference Guide to Professional Personnel Engaged in Consultation for Business, Industry and Government—Paul Wasserman and Janice McLean, Eds.—Gale, 1973, 2nd ed., 1,030 p., $45. Offers biographical information about more than 7,500 individuals who perform consulting activities, both full-time and occasional.

**THE WILDERNESS HANDBOOK**—Paul Petzoldt—Norton, 1974, 286 p., photographs, $7.95. Contains a lifetime of experience in techniques to increase physical stamina, prepare for safe and efficient camping and climbing, with specific advice for groups exploring the wild outdoors.

# Science® News

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## Of the Week



## Research Notes



## Articles



## Departments



**COVER:** Flood-damaged airplanes are being deliberately crashed from the old Lunar Module drop-test rack (1) at NASA's Langley Research Center to study the survivability of general aviation aircraft. Swung down on cables (2) to vary the crash angle and speed, the planes hit nose first (3), but early tests have shown a major second impact when the fuselage drops down behind (4 and 5). Long skids (6) add abrasion. (Photos: NASA)


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# To the Editor

### Sickle-cell coverage

Your publication is the highlight of the week to me.

I've never had occasion to criticize anything in SCIENCE NEWS that's in my particular interest. I do, however, have a question now on completeness of coverage. The subject is sickle-cell anemia. The detective story is incomplete and deserves more coverage due in fairness to those suffering from the disease.

In the letter written by Robert M. Nalbandian, M.D., ("Out of the swirling controversy," SN: 6/8/74, p. 363) compliments are extended for clarification of cyanate research results. May I suggest, for the interest of the sufferer, that coverage of nutritional research be reported as it appears in the Nov. 26, 1973 AMERICAN JOURNAL OF CLINICAL NUTRITION in an article by Robert G. Houston.

Genetically the sickle-cell trait gives protection against malaria. The African groups therefore find it beneficial. But! there is very little sickle-cell anemia in Africa. Houston successfully relates this to the cyanate content of the ethnic diet (yams, sorghum, millet and cassava) which provides the African with upwards of 1,000 milligrams of cyanate per day. The U.S. diet contains only 25 milligrams.

The masterful pen of Joan Arehart-Treichel would be perfect to close out this picture.

*Gerald W. Clarke*
*Oxnard, Calif.*

### It's a lopsided world

A note on "The mystery of the hemispheres" (SN: 4/13/74, p. 241) calls attention to the apparent replication of an asymmetry, or one-sided roughness, previously noted for the Moon and now seen on Mars and Mercury as a result of Mariner data.

It may be worth noting that, in terms of land and sea distribution—and therefore geologic phenomena—the earth is also quite asymmetrical. Viewed from a spacecraft in synchronous orbit over coordinates 10°S., 160°W. the earth would appear as a hemisphere almost entirely covered by water.

In earlier stages of continental drift this land/sea asymmetry would have appeared even more pronounced.

*Ronald Davis*
*Asst. Prof. of History*
*Western Michigan University*
*Kalamazoo, Mich.*

### For metrication

As a science magazine, I wish (if not advise) you would completely discontinue using the English unit system and use only the metric or SI system. The faster we get out of the English system, the better. We cannot do that if you and others maintain the habit of giving units in the English system.

I believe, though I don't know if it can be proven or disproven, that America would be at least 5 years ahead of its time today in science and technology if it had started with the metric system when it became available.

*Ernest Cruzen*
*Chemical Engineer*
*Eureka Co.*
*Bloomington, Ill.*

*(We would like to be all metric, but many of our sources quote English units. Conversion is messy and raises the question which are exact and which round numbers. There is an apocryphal tale from the early days of NASA an agency long hooked on English units: A bureaucratic type repeatedly bedeviled the celestial mechanicians to give him orbital data in English units. Finally they did. They recorded the velocity of a satellite in furlongs per fortnight.—Ed.)*

### Good job on Pluto

I was particularly impressed by the excellent job done by SCIENCE NEWS in summarizing my article on a possible neon atmosphere for Pluto (SN: 6/1/74, p. 353).

I have noticed that many newspapers and magazines, in attempting to condense an article, oversimplify it to the point of gross distortion. I was therefore pleasantly surprised to see how accurately my paper was reported. Keep up the good work.

*Michael H. Hart*
*Hale Observatories*
*Pasadena, Calif.*

### The Forest, not the Park, Service

SCIENCE NEWS seems to be perpetuating an unfortunate error regarding the alleged use of D.D.T. by the National Park Service to control tussock moths in the Pacific Northwest (SN: 3/30/74, p. 209, 6/8/74 p. 370).

In fact, it is *not* the U.S. Department of Interior, National Park Service, that contemplates this action but the U.S. Department of Agriculture, U.S. Forest Service.

*Milford R. Fletcher, Ph.D.*
*Ecologist*
*United States Department of the Interior*
*National Park Service*
*Santa Fe, N.M.*


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# NAS: President Needs Advisory Council

For two years, relations between the White House and the scientific community have steadily deteriorated. First came the resignation of Presidential science adviser Edward E. David, Jr. and the disbanding of the Presidential Science Advisory Committee (PSAC) (SN: 1/13/73, p. 20). The official explanation was that since science serves many areas of government, each branch should maintain its own technical staff and that whatever advice the President might need concerning "pure" science, he could learn from the head of the National Science Foundation. Hence, foundation director H. Guyford Stever was given the title of Presidential science advisor, even though he would remain, physically and spiritually, at NSF—a safe distance from the White House inner circle (SN: 1/27/73, p. 52).

Unofficially, that inner circle was known to be displeased at the outspoken oppisition of some PSAC members to the Vietnam war and with the generally anti-Administration view of many academic scientists. In fact, the new science adviser was not to report to the President directly, except on urgent matters, but rather to work through the Office of Management and Budget (OMB) and the office of then Secretary of Treasury, George Shultz. Cavalierly dismissed were objections that Stever inevitably faced a conflict of interest in his dual role as advocate (for NSF and "pure" research) and adviser (theoretically telling OMB how much money to allot to each technologically oriented agency, including his own).

Congressional concern over this arrangement grew as evidence mounted that Stever, in fact, almost never was allowed to see the President and as rumors persisted that Nixon's real personal adviser on matters of science was someone totally outside the Government, Bell Laboratories President William O. Baker, who had led the Science and Engineering Council for the Reelection of President Nixon (SN: 7/28/74, p. 52). In an interview with SCIENCE NEWS, Stever said he was trying to cooperate with Baker and keep alive the idea that "basic science is part of the whole structure" (SN: 12/1/73, p. 343), but concern over the effectiveness of this tenuous relationship grew with the urgency of the developing energy crisis and Congress has once again begun to hold hearings to see if some new structure of Presidential science advising ought to be legislated.

Last week that initiative received a powerful stimulus in a report issued by a committee of the National Academy of Sciences. While expressing admiration for Stever's game efforts to fulfill his dual capacities, committee members found the current arrangement "inherently unsatisfactory and insufficient." In its place was proposed establishment of a Council for Science and Technology (CST) whose penetration of the Administration infrastructure would go beyond that of any previous arrangements.

Led by Chairman James R. Killian, Jr., who had served as President Eisenhower's science adviser, the committee recommended that CST be established as a staff agency in the Executive Office of the President and be composed of at least three members, selected by the President, who should have his confidence and enjoy direct access to him (compared to PSAC, whose members were generally considered outsiders). The council chairman should serve as a member of the powerful Domestic Council, the committee advised, and participate actively in the work of the National Security Council. Further, CST should be given a voice in foreign affairs by working with the Secretary of State in matters relating to international scientific and technological cooperation, and should work closely, as equals, with OMB in deciding what funds to allocate to various competing Government agencies.

In addition to advising the President and his staff on daily technical matters, the committee recommended that CST submit a yearly report on major developments in science and technology that might have significance for national policy. As a corollary suggestion, the committee recommended that some separate body be established to conduct longer range policy research and analysis.

Chairman of the House Committee on Science and Astronautics, Olin E. Teague (D-Tex.) announced that the committee's staff would begin to draft legislation along the lines of the committee's recommendations. Having thrown the last science advisory committee out of the White House and personally sanctioned the rise of OMB in policy making areas, President Nixon might well veto such a measure, but the White House is giving little consideration to this whole area at the moment. Vice President Gerald Ford, should he rise to the Presidency, is expected to be more responsive to such advisory bodies as the proposed CST.

According to the committee report, establishment of a Council for Science and Technology would help assure that responses to such crises as the oil embargo would possess a sound technological and scientific base. In addition, a scientist must feel "the future in his bones" (C. P. Snow's phrase), and CST would help assess the possible impact of new discoveries and be able to recommend proper steps to see that the impact is beneficial.

The Killian report was "strongly endorsed" by the Academy Council at its June 9 meeting and Academy President Philip Handler told SCIENCE NEWS the success of the proposed CST would depend on whether it could become "a part of the whole team" in the White House. □

# Vannevar Bush, first science adviser, dies

Vannevar Bush, the first Presidential science adviser, who marshaled American technology for World War II and then laid the groundwork for subsequent Federal support of scientific research, died last week in Belmont, Mass. The 84-year-old electrical engineer and master scientific administrator had been in failing health for over a year, then suffered a stroke in early June and finally succumbed to pneumonia.

Bush epitomized the application of Yankee ingenuity to the complexities of advanced technology. A descendent of New England whaling captains, he loved nothing better than watching song birds near his summer house on Cape Cod and he invented a bird feeder that would support the weight of the small songsters but not any heavier bird, such as a pigeon. His ingenuity earned him hundreds of patents and, coupled with considerable enterprise, helped him achieve respectable wealth through the formation of several companies, including the forerunner of Raytheon.

But his special talent was techno-

MIT

*Vannevar Bush, in an old picture, watches his early analog computer work.*

logical foresight and a persuasive managerial skill. Over a year before Pearl Harbor, he had convinced President Franklin Roosevelt of the necessity of establishing a National Research Defense Committee to help the nation's armed forces catch up with Hitler's sophisticated war machine. The committee was replaced the next year with a more permanent Office of Scientific Research and Development, which, under Bush's leadership, not only began the push to develop an atom bomb and encouraged development of radar, rocketry and the mass production of antibiotics, but for the first time brought the highest level of scientific advice directly into the White House.

At the war's end, Bush immediately began a campaign to continue Federal support of science for peacetime uses. Arguing that the vast pool of scientific expertise brought together during the war must not now be allowed to dissipate, and that the GI Bill could be used to train the next generation of scientists, Bush declared (SN: 12/22/45, p. 386): "We undoubtedly have a new stock of dammed-up ideas. It will be interesting to watch what happens as the dam breaks." The upshot of his campaign was creation of the National Science Foundation.

Though he invented the forerunner of the analog computer—a great, whirring mechanical and electronic monster with 150 motors—he was modest concerning the impact of his own ideas on the many projects he supervised. "Not a single idea of mine ever amounted to shucks," he once wrote, yet he developed the system of "mission-oriented" research that led to almost a mass production of ideas and inventions. The eventual result was "push-button warfare" (a phrase he hated), and though he was a lifelong supporter of a technologically strong military, toward the end of his life he said they were overdoing things. For his services, he received the Medal of Merit and National Medal of Science. □

## Gene therapy: One step more

During 1971, a virus was used to introduce a specific gene into a mammalian cell. The gene provided genetic information that was missing in the cell —information needed to make a particular enzyme. After the gene was provided by the virus, the cell started producing the previously absent enzyme and passed the ability to do so on to succeeding generations of cells. The investigators were Carl R. Merril and John C. Petricciani of the National Institutes of Health and Mark R. Geier of George Washington University (SN: 10/23/71, p. 281).

This remarkable step toward human gene therapy was closely followed by another one. Pradman K. Qasba and H. Vasken Aposhian of the University of Maryland School of Medicine showed that not only could a virus deliver missing genes (DNA) to human cells, but that the missing genes indeed ended up in the cells' nuclei (SN: 10/30/71, p. 291).

Petricciani has now found that synthetic DNA, as well as viral DNA, can be incorporated into mammalian chromosomes. This achievement is still further proof that human gene therapy is possible. Or as Petricciani puts it, "It's another little bit of evidence that if you introduce foreign genes into cells, they can interact with the normal DNA of the cells." Petricciani is now with the Food and Drug Administration. He reports the achievement along with his FDA colleague Rosalyn M. Patterson in the June 14 NATURE.

Actually Petricciani and Patterson did not do these experiments on human cells, but on cells from the Indian barking deer. A human cell has 46 chromosomes, the deer cell only seven, so that the latter is a lot easier to work with. They inoculated the deer cells with synthetic DNA, that is, with DNA whose nucleotide composition was entirely known. That way they knew exactly what genetic material they had.

They then looked at the chromosomes to see whether the synthetic DNA had been incorporated into them. Here they used a chromosome staining technique that allows scientists to distinguish the shape of each chromosome distinctly (SN: 9/25/71, p. 202). The technique showed that the synthetic DNA was indeed attached to the chromosomes.

If the deer cells can pass the synthetic DNA on to progeny cells, then, Petricciani and Patterson say, "it should be possible to use synthetic nucleic acids in gene therapy rather than viruses which carry unnecessary and often unwanted genetic information in addition to that which may be therapeutically useful." □

Petricciani and Patterson/Nature

*Six normal chromosomes (left). Chromosomes with new DNA on them (arrows).*

# Teenage illegitimate births high

Among today's teenagers premarital sex is a relatively common event but birth control is unfortunately not. Two Johns Hopkins sociologists have found that 30 percent of all American women between the ages of 15 and 19 experience premarital intercourse. This results in pregnancy for about a third of the women involved. Three-fourths of all first pregnancies of American teenagers are conceived before marriage.

"To marry and then conceive is the exception among teenagers," comment Melvin Zelnik and John F. Kantner in the FAMILY PLANNING PERSPECTIVES, a technical journal of the Planned Parenthood Federation of America, after studying a nationwide survey of young women taken in 1971. Projecting from the national probability sample, Zelnik and Kantner estimate that out of 2.6 million teenagers that had premarital sexual experience, 1.1 million became pregnant and 831,000 became pregnant out of wedlock. Birth control is rarely used. Among those that became pregnant, only 13 to 16 percent used any birth control. Those who did, frequently used an ineffective one such as withdrawal and douche.

"By race," the authors say, "differences in the prevalence of premarital first pregnancies mirror differences in the prevalence of premarital intercourse: proportionately twice as many blacks as whites have premarital intercourse, and twice as many of these become pregnant. The result is that four times as many black teenagers experience pregnancy than whites."

Whites are six times more likely than blacks to marry before the child's birth. Among the teenagers that married, most married the putative father of the child but about 40 percent married someone else.

Among those who did not marry before the conclusion of the pregnancy, two-thirds had live births; about one-fifth had abortions. The authors report that blacks, however, were nearly two times more likely to have a live birth and seven times less likely to have an abortion than whites, though changes in abortion legislation may have changed these findings in the last three years. In addition white teenagers were nine times more likely than blacks to give up their babies for adoption.

Although wanted and unwanted childbearing among married persons has decreased in the United States in recent years (SN: 6/22/74, p. 397), out-of-wedlock births have continued to increase, with illegitimacy rates among teenagers rising most rapidly.

In a companion article, Leo Morris of the Department of Health, Education and Welfare's Center for Disease Control in Atlanta estimates from the Johns Hopkins figures that there are between 1.4 and 2.3 million never-married teenagers who are risking unintended pregnancy. Sixty to 75 percent of these women are without access to contraceptive service. "Clearly, there is a significant gap between estimated *need for* and *utilization of* family planning services among never-married teenagers in the United States," Morris says. When services for teenagers are available, he observed, "teenagers appear willing to use facilities responsive to their needs. . . ." □

# ALADDIN: A lamp for the atmosphere

You'd have thought the attack was coming any minute. The flight center on tiny Wallops Island, Va., is hardly the flagship installation of the National Aeronautics and Space Administration, but bristling with rockets last week it looked like the setting for the Final Showdown. Nikes, Tomahawks, Viper-Darts, Super-Lokis and a host of other ex-weapons and multipurpose boosters craned upward towards the gray sky, aimed at a single target—the air.

They were the armament for Project ALADDIN '74, a vast but concentrated study of winds, temperatures, ion concentrations and other characteristics of the upper atmosphere, too high for ballons to measure and too low for satellites. There were two previous ALADDINs (the name stands for Atmospheric Layer And Density Distribution of Ions and Neutrals), conducted in 1970 and 1972 from Eglin Air Force Base in Florida, but they involved the launch of only six and nine sounding rockets respectively. ALADDIN '74 was a monster.

In the space of 24 hours and 20 minutes during the weekend, 54 rockets were launched from Wallops Island, an average of one every 27 minutes. The limited launch crew—the place is a far cry from the heyday of, say, Florida's Kennedy Space Center—was augmented with extra NASA and Air Force personnel plus reinforcements from the National Oceanic and Atmospheric Administration. Researchers came from England, Canada and West Germany. Even eight visiting Italian radar and telemetry trainees were drafted into the cause. Many of the scientists, engineers and technicians worked more than 30 hours without sleep.

The mission was a spectacular. Twelve of the rockets injected huge chemical clouds into the atmosphere as tracers, so bright and so large that they were sighted from the southern states all the way up to New England. A double injection of barium and trimethyl aluminum, for example, produced a glowing green cloud, with the brightness of the barium indicating variations in electric fields and the trimethyl aluminum marking temperature profiles.

Some of the rockets ejected free-falling spheres, which could be tracked during their descent to show winds and density variations in the atmosphere. Plasma probes, mass spectrometers and other instruments were all part of the program, whose results are expected to be so voluminous that they may not be published until autumn of 1975.

The rockets were investigating the atmosphere between about 35 and 100 miles up. Although this is below the reach of almost all orbiting satellites, one, Atmosphere Explorer C, gets as low as 84 miles, and the rocket launches were originally timed to coincide with the probe's low passage over Wallops. Murky skies delayed the project a week, but it just managed to squeeze in before the satellite moved on to a less desirable position.

Besides measuring mere winds in the atmosphere, the experiments aboard the rockets were planned to study wind shear (one layer of wind blowing past another), temperature variations, diffusion and mixing patterns, composition and other features. In addition, heavily instrumented aircraft cruised the area, photographing and recording data of their own, and ground-based studies were carried out at the same time, in part to provide correlations with past programs that had not had the benefit of the rocket armada.

As in most large-scale meteorological efforts, the name of the ALADDIN game is "modeling." The atmosphere obviously changes too often for numerical measurements from specific locations to be particularly useful in themselves. Instead, they must be incorporated into a numerical model that can be used to show what is going on (or to predict what will be going on) when a given set of conditions appears.

"We don't have adequate models of a quiet atmosphere or normal ionosphere," says Russel Philbrick of the Air Force Cambridge Research Laboratories, which have a major research role in the operation. "The ALADDIN '74 program will provide the data base which can be used for developments of new atmospheric and ionospheric models and many theoretical studies of atmospheric properties. Because of the thoroughness of the investigation, the results . . . will provide a baseline for comparison of past and future . . . investigations." □

# Pesticides inhibit estuarine microbes

Farmers have used pesticides on food crops for decades. Although scientists synthesized and tested various chlorinated hydrocarbons in the laboratory, they are still discovering the wide-ranging and frequently damaging effects these chemicals can have on natural ecosystems.

Two Harvard microbiologists, Ralph Mitchell and Fraser Walsh, report in the June 14 NATURE on one possible effect.

Mitchell earlier studied microbial ecosystems in tidal regions of the eastern seaboard of the United States. Unlike heterogeneous animal or plant populations which can become unbalanced by the intrusion of a new species or a change in the physical environment, microbial populations have an ecological "righting" mechanism. Microbial predators, rather like a combination of tiny soldiers and miniature garbage men, weed out invaders, as well as the old and infirm members of the native population, to prevent imbalances from persisting. Mitchell found this cleanup operation functioning at full speed in areas where municipal sewage wastes are dumped into tidal pools.

He found that the intestinal bacterium *Escherichia coli*, carried by the billions in sewage, is parasitized by certain bacteria and consumed by certain amoebas. Sewage also carries infectious intestinal bacteria such as *Salmonella typhimurium* and these, too, are expunged from tidal basins by predatory bacteria.

Mitchell and Walsh also reported earlier that the cleanup bacteria recognize their prey chemically and move toward exudates given off by the intruders. This process is called chemotaxis.

In their current report, Mitchell and Walsh state that chlorinated hydrocarbons, which are appearing in the sea in greater and greater concentrations, inhibit the chemotactic mechanism of the predatory bacteria. This fact may "directly affect estuarine self-purification rates," they write.

They tested the percentage of *E. coli* killed by marine predators in the presence of different levels of the pesticide 2,4-D and o,o-Dichlorobiphenyl (a product of the interaction of pesticides with natural materials in waterways.) When the cultures were continually shaken (to simulate natural conditions) a significant decrease in the percentage of *E. coli* killed was observed. They suspect that the pesticide and pesticide-product interfered with the chemotactic response of the predators to the *E. coli*.

The concentrations of pesticides found in some estuaries are already within a factor of 20 of those which cause the inhibition, they state.

"What we have described," Walsh told SCIENCE NEWS, "is a generalized phenomenon. We chose *E. coli* as a model, and observed only certain predators, but any number of predators might use this system. In estuarine regions, if the levels of chlorinated hydrocarbons affect the interactions of predators and prey, then the food chain would be altered in some way. It would not necessarily be detrimental, though.

"Some species which depend on a very specific diet may be detrimentally affected, but where the organism is capable of adaptation, there might not be adverse effects. One thing that has been observed already is a die-off of diversity of species in 'polluted' regions and an increase in the populations of a single, adaptive life form. Whether this has been a result of chemotactic inhibition or direct toxicity from the pollutants is unknown."

Commenting on whether the disruption of the bacterial-predator system could lead to outbreaks in shellfish containing toxic concentrations of viruses such as infectious hepatitis, Walsh said, "If you take our research to be a model, although we didn't study viruses, they also might not be destroyed to the extent they should be." □

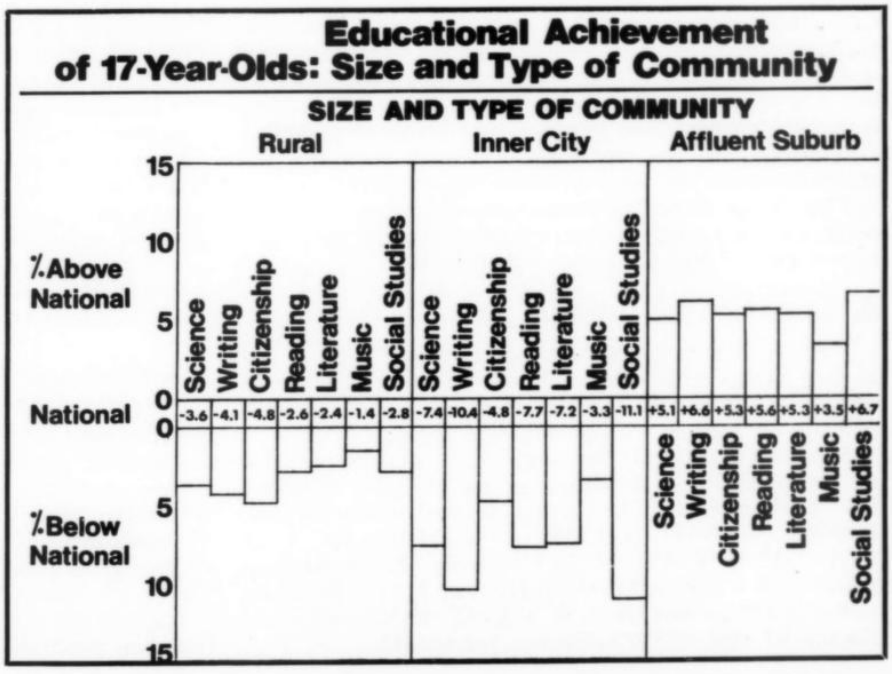
# Science education slips in U.S.

How often do you read about science or scientists? In 1969-70, male students were 13.4 percent more likely than female students to indicate that they read such material outside of school. By 1972-73, the gap between the sexes had narrowed to three percent. But this is almost the only encouraging sign for science education in the recently released National Assessment of Educational Progress.

The report is part of an on-going attempt to measure growth or decline that takes place in education in the United States. The project began in 1969, and since then 500,000 students across the country have been tested. A second round of tests has now begun and results of the science tests indicate a general decline in scientific knowledge.

In addition to the fallout in science, the survey has found that students who are poor or black, who live in the inner city, in rural communities or in the Southeast are significantly below national levels in most of the subjects traditionally taught in the nation's schools. Most educators have suspected this but now it has been objectively documented. In contrast, young people who live in the Northeast or in suburban communities or whose parents have had the advantage of post-high school education, consistently demonstrate higher levels of skills and knowledge than does the nation as a whole.

By 1975, the second round of tests will have been completed in all learning areas being tested. Since these will be the first national data of their kind, educators and policy makers are evaluating the findings to determine whether achievement levels are satisfactory. What is already obvious and unsatisfactory, the report says, is the inequality in education that exists between different areas of the country. □



# Physical Sciences

## Leptons with size proposed

Current physical theory tends to treat the leptons, the class of particles that respond to the so-called weak force, as if they had no spatial extent. The electron, the positron, the muon are treated as if they were geometric points. The idea causes some serious conceptual difficulties, but the difficulties have usually been overridden by the consideration that the theory works.

But not quite any more. A shadow has fallen, cast by the results of certain experiments in which electrons and positrons collide. The cross sections for the production of certain kinds of particles (hadrons) in those collisions do not come out quite what theory says they ought to be.

One suggested solution to the difficulty is presented in the June 24 PHYSICAL REVIEW LETTERS by O. W. Greenberg and G. B. Yodh of the University of Maryland. They suggest that leptons, after all, have a finite size. The dimension would be on the order of $6 \times 10^{-17}$ centimeter. Greenberg and Yodh present an argument to show that the existence of such a size would add a certain component to the interaction that takes place between two leptons as they approach each other and that this component makes the cross sections for hadron production come out to the experimental value.

## And still no heavy leptons

Another problem involving leptons is that there are only four of them (eight if you count antileptons). The electron, the muon and two kinds of neutrino are all. Newly proposed theories, which are attractive to many physicists because they present a treatment that tends to unify the phenomena under control of the weak forces with those under control of electromagnetism (SN: 5/25/74, p. 340), predict the existence of more leptons, heavier than the known ones.

Up to now experiment has consistently failed to find any. A new experiment, done at the Fermi National Accelerator Laboratory in Batavia, Ill., extends the range of masses searched for and still comes up negative. As B. C. Barish of California Institute of Technology and seven collaborators put it in the June 17 PHYSICAL REVIEW LETTERS, previous experiments searched for leptons with masses up to 2.5 billion electron-volts. (This is about ten times as heavy as the muon, the heaviest known lepton.) But some theoretical models allow lepton masses up to seven billion electron-volts, so the experiment of Barish et al was designed to search the range between two and seven.

They report finding no such leptons with masses in this range, and they conclude that any heavy leptons must have masses greater than 8.4 billion electron-volts.

## A fast flying pulsar

Theories of what pulsars are tend to regard them as fast moving objects. Pulsars are supposed to be the remnants of supernova explosions, and the explosion could blow the remnant off position with quite a high speed.

If pulsars are moving fast, they should show appreciable proper motion (motion across the line of sight) in only a few years' observation. In a recent ASTROPHYSICAL JOURNAL LETTERS (Vol. 189, p. L119) R. N. Manchester, J. H. Taylor and Y. Y. Van of the University of Massachusetts report such a motion for the pulsar PSR 1133 +16. If the pulsar is 130 parsecs away, as believed, the velocity across the line of sight is 380 kilometers per second.

# Chemistry

## Hot diamonds melt an old theory

The question of how diamonds are formed has always intrigued man. Besides his basic curiosity, if he knew how they were formed in nature, perhaps he could find them more accurately or produce more perfect ones himself.

An old theory may go by the wayside as a result of research reported in the June 14 NATURE by two chemists, R. E. Langford and Charles E. Melton, and a geologist, A. A. Giardini of the University of Georgia at Athens.

It had been proposed that diamonds were formed by the reduction of carbon dioxide to pure carbon. Pyrrhotite, an iron-and-sulfur-containing mineral occasionally found in diamonds, was thought to be active in the reduction process. Iron could accept the liberated oxygen, sulfur gas would be formed and carbon would be crystallized.

The Georgia team reasoned that if this was the diamond-forming process, then sulfur inclusions should be found in diamonds. To test this, they heated diamond fragments in the presence of pure oxygen. Any included sulfur would then form sulfur monoxide or dioxide and could be detected.

No sulfur compounds appeared. This suggests, the team said, that pyrrhotite was not involved in diamond formation, except perhaps in isolated circumstances.

So for geochemists, it's back to the laboratory and the half a dozen other theories of diamond formation.

## Chloro-organics and fish hatching

The treatment of municipal sewage with chlorine before it reaches rivers and lakes has increased during the last decade. More than 100,000 tons are added annually. Unfortunately, the chlorine forms many stable organic compounds after reaching the surface water, and scientists know very little about their effects on animal and plant life.

Four Oak Ridge National Laboratory scientists, C. W. Gehrs, L. D. Eyman, R. J. Jolley and J. E. Thompson, report in the June 14 NATURE on the effects of two of these compounds on the hatching success of carp eggs. They added 4-chlororesorcinol and 5-chlorouracil to newly fertilized carp eggs. Some of the eggs were "water-hardened," or left undisturbed for 30 minutes before addition of the chemicals, and some were "nonwater-hardened," or fertilized right in the test solutions. (The latter more closely duplicates conditions in natural waterways.)

The team found that the hatchability of the nonwater-hardened eggs was "significantly decreased" by doses of the toxins as low as .001 milligrams per 100 milliliters of water. That level is below the estimated concentrations in sewage treatment plant effluents.

The results are an important first source of data on the toxicity of stable chlorine-containing organic compounds and should be considered when judgments are made on the potential toxicity of chlorine, the team says.

## Noble-gas compounds

Xenon, a noble gas, was once thought to be totally inert. Experiments with the highly electronegative element fluorine disproved this, and xenon-fluorine bonds were formed. Now, two Kansas State University chemists, Darryl D. DesMarteau and Robert D. LeBlond, have succeeded in synthesizing a compound with a xenon-nitrogen bond. Through a complicated series of reactions that take four days to complete, a compound called fluoroxenonimidobis (sulfuryl fluoride) is formed. They will also try for xenon-carbon bonds in their study of unusual compounds.

# Biomedicine

## ATP: The finger in the dike

Enzymes leak out of cells that have been damaged by viruses, toxic chemicals, trauma, lack of oxygen, cancer or other factors. The leakage may occur because the cells fail to synthesize ATP in adequate amounts, J. H. Wilkinson and Jean M. Robinson of the Charing Cross Hospital Medical School report in the June 14 NATURE. ATP is cells' major energy molecule.

In an attempt to devise a model to study factors affecting the liberation of cell enzymes, the London chemical pathologists recently studied the effects of phospholipases on enzyme release in rat and human white cells. In those experiments, the porosity of the cell membrane was increased, leading to the outpouring of enzymes. They then turned to investigating the actions of a number of substances that might protect the cell against the effects of phospholipases as judged by a reduction in the leakage of the enzyme lactate dehydrogenase. One of these was ATP.

"The protective effect of ATP . . .," they conclude, "is consistent with the view that maintenance of cell membrane integrity is associated in some way with the energy content of the cell. This indicates that any condition that leads to a diminution of intracellular ATP is likely to result in leakage of enzymes and other proteins."

## Coffee creates anxiety

A 37-year-old male was referred to a psychiatric outpatient clinic with a history of "chronic anxiety." Symptoms included dizziness, tremulousness, apprehension, frequent diarrhea and difficulty falling and remaining asleep. Three complete medical workups revealed nothing, and various drugs gave no relief during a 10-month period. Finally, when questioned by a physician, the patient reported consuming at least 14 cups of coffee and three or four colas per day plus a bedtime cup of cocoa. Total caffeine intake was about 1,200 mg per day (250 mg is considered a large dose).

This case was reported at the recent meeting of the American Psychiatric Association by John F. Greden of Walter Reed Army Medical Center. Greden was warning of the dangers of undiagnosed caffeinism. When the patient reduced his intake of caffeine for four weeks, his anxiety went away.

## The making of an antibody

Five kinds of human antibodies (immunoglobulins) are now known—IgG, IgD, IgE, IgA and IgM. Each antibody comprises from 4 to 20 polypeptide chains. The biggest antibody, IgM, is star-shaped. Each arm of the star contains two heavy polypeptide chains and two light polypeptide chains. As if this structure weren't confounding enough, still another polypeptide chain was recently discovered to be stuck onto IgM. It's called a J chain.

The J chain becomes attached to IgM during its assembly, specifically to the two heavy chains in each arm of the star. But where on these chains exactly? Jiri Metstecky and Ralph E. Schrohenloher of the University of Alabama wanted to find out.

They report in the June 14 NATURE that the J chain and the heavy chains are connected by a disulfide bridge between cysteine amino acids on the J and heavy chains. Exactly how this chemical connection might help the J chain organize the IgM molecule into a star remains to be determined.

# Aerospace

## Aircraft operation near terminals

A "blind" second cockpit filled with advanced instrumentation has been built into the passenger section of a Boeing 737 jetliner, in a study of aircraft operations near airports.

Data displays from the windowless, rear cockpit will be provided in the forward cockpit so that the regular pilot can take over in the event of a problem, but it will be possible for the rear crew to make completely automatic approaches from their own flight deck. In addition, a variety of experimental techniques and equipment will be evaluated, including electronic displays, flight controls, guidance systems and airport-vicinity operations procedures.

NASA, which calls the plane its TCV (Terminal Configured Vehicle—everything the space agency touches turns to jargon), plans also to use it in human-factors studies such as pilot workload and crew interaction. The overall TCV program covers the aircraft end of a broad air operations research program for which the Department of Transportation and the Federal Aviation Administration are working on the ground equipment and air-traffic-control procedures.

## Putting the heat to Helios

Helios, a space probe scheduled to go closer to the sun than any other manmade object ever launched, has successfully survived a ground test that exposed it to temperatures believed to be as high as any it will face during its mission.

In a vacuum chamber at Jet Propulsion Laboratory, a battery of mirror-focused xenon arc lamps poured out energy equivalent to 11 times the solar intensity at the outer edge of earth's atmosphere. At the same time, the probe was spun at 60 revolutions per minute to distribute the heat load, just as it will be distributed in flight. During the test, parts of the spacecraft reached—and survived—temperatures up to 700 degrees F. Helios, to be launched in October, will pass within 28 million miles of the sun.

## Mercury probe heads for daylight

The choice has been made. When the Mariner 10 spacecraft comes around on Sept. 21 for its second encounter with Mercury, it will fly by the planet's sunlit side, rather than taking the night flight as it did on its first flyby in March.

The other option would have been a darkside pass to provide additional data on the interaction between the solar wind and Mercury's previously unsuspected magnetic field. The sunside pass will enable television photography of the planet's south polar region, not covered in the first encounter, as well as providing better viewing angles of some areas already photographed to study the height of surface features, reflectivity and other characteristics.

Another important factor in picking the sunside route was that it will enable a third encounter in late March of 1975, during which the darkside studies can be carried out. Doing the darkside pass first would not allow the third encounter, says Mariner project scientist James Dunne of Jet Propulsion Laboratory.

Mariner will fly past the planet at a distance of about 47,360 kilometers in the September encounter, yielding photo resolution of about one kilometer. The initial encounter came to within 689 km. of the surface, giving 100-meter resolution, but the greater distance is desired on the second pass to give the cameras more time at their closest approach. The 1975 encounter will be "as close as we can make it," says Dunne, and certainly less than 1,000 km.

# Crash City For General Aviation: What Happens Beside *Splat?*

**Dozens of aircraft are being deliberately crashed into the ground as the FAA and NASA study the anatomy of impact.**

by Jonathan Eberhart

Out of the flood—straight into the ground.

As spring was completing its segue into summer in 1972, Hurricane Agnes smote the eastern United States a mighty blow, destroying lives and homes, creating overnight islands and wreaking havoc everywhere it went. One of the casualties was an airplane factory in Lockhaven, Pa., where Piper Aviation had been building small single- and twin-engined craft for the general aviation business. Small planes, but many of them worth somewhere in the neighborhood of a quarter million dollars apiece.

Agnes' contribution to the factory was instant flood. As the water inundated the aircraft—some still on the assembly line, others awaiting sale or delivery—silt worked its way into seams, overlapping joints and rivet holes. The water alone would have been enough to cause worries about the hastening of metal fatigue, but in addition it carried corrosive chemicals washed down from a nearby paper plant. After inspecting the damage, the Federal Aviation Administration deemed the aircraft unflightworthy, an irretrievable loss to Piper in the millions of dollars.

Not that it will make Piper's accountants any happier, but some good has come out of the tragedy. Buying the suddenly unflyable aircraft at scrap prices, the FAA and NASA have embarked on the first large-scale study of the "crashworthiness" of general aviation aircraft—complete with real crashes.

At NASA's Langley Research Center in Hampton, Va., stands a huge construction of girders, one and a third football fields long and 240 feet high, looking for all the world like the frame of a swing set in some mythical playground of giants. It was built and first used for drop tests of the Apollo lunar module, to be sure the spidery spacecraft could withstand the shock and vibration of landing on the moon. Now it's collision city, two crashes into a years-long program of deliberately hurling the grounded planes from the

*Engineer examines dummy crewmen following 60-mph crash.*

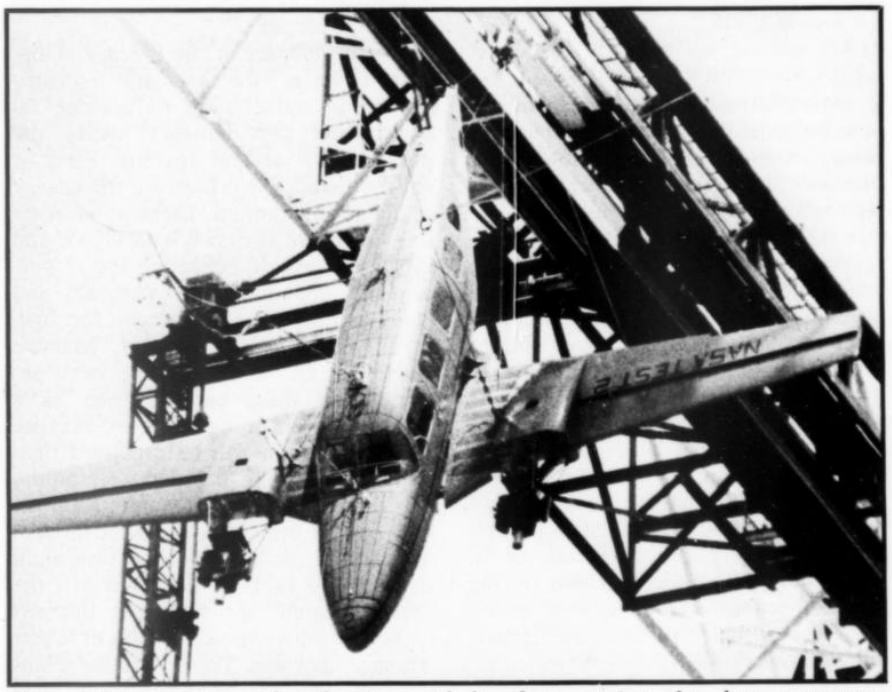

NASA

*Test director Victor Vaughn checks "wreck" at Langley.*

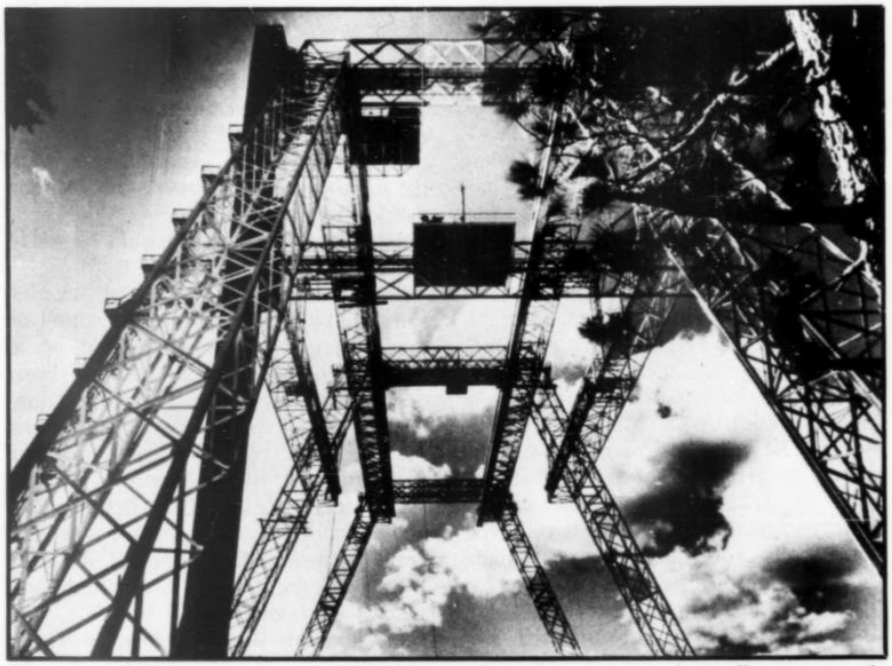
heights of the frame into the hard concrete below.

Both Government agencies have been quick to point out, particularly to allay earlier fears of the General Aviation Manufacturers Association, that the name of the game at Langley is research, not consumer testing. The purpose of the calculated drops is to learn what happens when a light plane crashes, not to find fault with anyone's designs. There has always been a shortage of real data on crash responses in light planes, so the FAA's safety and construction standards for general aviation have had to be based on indirect information such as materials tolerances and after-the-fact reconstructions of accidents. Research has been largely confined to individual components and partial structures, and to computer simulations based on these limited results.

Now NASA has 34 real, live planes to drop from its Langley torture tower, laden with sensors, crewed by instrumented dummies and recorded by 20 high-speed movie cameras. Another 19 of the flooded fleet are at the National Aviation Facility Experimental Center in Atlantic City, N.J., where the FAA plans to smack some into a shock-absorbing wall on a compressed-air sled and catapult the rest into a hillside. Three more are in FAA hands for similar testing in Oklahoma City. "If we were in a position where we had to go out and buy these airplanes," says the FAA's Herb Spicer, "we might not be in this test program."




*Except for engines and tail, it's a whole plane getting the drop treatment.*



*Towering 240 feet in the air, NASA torture rack once tested Apollo mooncraft.*

The first two crashes on the Langley rack did not use planes at all, but "iron maidens" made of steel I-beams fastened into the approximate shape of fuselage and wings. As the first steps in a five-year program, they were needed to check out the instrumentation, the cameras, and even the method of dropping the planes.

The drop technique is far more complicated than merely pushing the test aircraft off a roof. The program is supposed to cover crashes over a range of angles up to 60 degrees and speeds from barely moving (such as in the case of a collapsing landing gear) to at least 60 miles per hour. To do this, the planes are hung like pendulums from cables mounted at several points on their structure. Changing the length of the cables and the arc through which the planes swing varies the force and angle of the impact. The problem was made still more difficult when NASA adopted a suggestion by the General Aviation Manufacturers Association to vary the pitch—the difference in height between the plane's nose and tail—in the tests. In addition, so that the planes would be in free fall when they struck the ground, carefully timed explosive bolts were provided to disconnect the cables just one tenth of a second before impact.

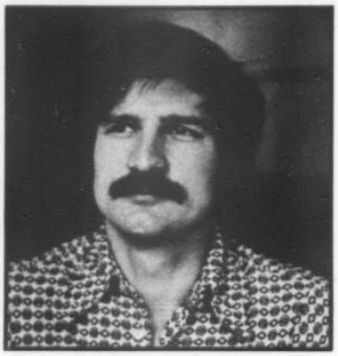
The instrumentation is a story in itself. Fifty accelerometers measure the forces on different parts of the aircraft during the fraction of a second at and after the crash. Realistic dummies, also instrumented, simulate the flexibility, weight distribution and breakable joints of human occupants. Three cameras in the cockpit and 17 more on the ground and on the test rack film the impact and its effects at up to 8,000 frames per second, to show the sequence and speed at which the energy of the crash works its way through the structure—and its occupants. (In Oklahoma City, where the FAA does much of its human factors testing, the dummies are even more realistic, including such features as concussions and the amount of protection afforded by the rib cage.) The instruments in the planes and the dummies are connected to a recording device by an umbilical cable that stays attached during the crash but disconnects during the skid that follows.

The two agencies have different responsibilities in the test program. NASA's domain is the airframe—the main aircraft structure—while the FAA will analyze data on the dummies, seats and restraint systems such as lap belts and

*Continued on Page 15*

# Breeder Reactors

## A Faustian Dilemma: Unlimited Power Or Unparalleled Risks?



*Tom Cochran: Breeder critic*

**by Janet H. Weinberg**

While alternative energy technologies are discussed with varying degrees of interest by the public and industry, the Government is quietly and heavily funding its priority alternative, the liquid metal fast breeder reactor (LMFBR). President Nixon told Congress in 1971 that "Our best hope for meeting the nation's growing demand for economical clean energy lies with the fast breeder reactor." The Atomic Energy Commission (AEC) has since devoted a large portion of its budget and attention to research, development and justification of the breeder.

Later this month, public hearings will begin on the draft version of an environmental impact statement the AEC issued in March on the LMFBR program. Since the draft report was made public, the AEC has received 1,500 pages of response. Under the National Environmental Protection Act, these reactions must be published along with the commission's responses in the final draft of the report, expected to come out in early fall. Public hearings must also be held, and many AEC officials and LMFBR opponents are gearing up for them now. It seems an appropriate time to review the breeder program and the controversies surrounding it.

Although the breeder is the Government's priority alternative to fossil and conventional nuclear power plants, it is not the alternative of choice in many circles. Breeder critics object to many technical aspects that are common to it and light-water power plants, but also to some that are generic to the breeder. For this reason, a quick review of how the breeder works might be helpful before considering the specific objections.

Sustained, controlled nuclear fission depends first on the tendency of elements such as uranium and plutonium to emit neutrons in the course of fission. In order for controlled fission to occur, an average of one neutron per fissioned atom must strike another fissionable nucleus. The uranium isotope U235, is generally used in conventional nuclear power plants as the fissionable fuel. More than one neutron, usually about 2.5, is emitted, so other substances are made available to absorb the extra 1.5 neutrons and to slow all of the neutrons so at least one will have a good chance of finding its target. Control rods made of neutron-absorbing boron, and water, which both cools the reactor core and slows down the neutrons, are used to moderate and control the reaction. As in fossil fuel plants, heat released by the fission reactions is used to boil water, make steam, drive turbines and generate electricity.

Almost since man began to understand nuclear fission and its inherent potential for energy production, he has theorized that the breeding of fuel could be accomplished. If the extra 1.5 neutrons were used to turn fertile fuel (such as U238, Pu240 or Th232) into fissionable fuel (such as U233, Pu241 or Pu239) he would gain back what he used up, plus some. This he has essentially been able to do in test breeders and proposes to do on a commercial scale.

In a breeder reactor such as the LMFBR, no moderator is used, thus the reaction is considered "fast." An average of one neutron from each fuel atom (Pu239 is used) carries on a chain reaction with other plutonium atoms. The extra 1.5 neutrons are absorbed by a blanket of fertile material such as U238, which then decays rapidly to form Pu239. This is removed periodically from the reactor and made into fuel for other breeders or for light-water reactors which can also run on Pu239. Flowing around the immensely hot fuel rods inside the reactor core as a coolant is molten sodium, a silvery metal with some useful properties. It does not moderate neutrons, and thus does not interfere with the fast reaction; it is a good heat-transfer agent, and it also has a very high boiling point. The reactor can operate at a high temperature (between 800 and 1,050 degrees F.) without requiring high pressure to prevent the sodium from boiling. This eliminates the necessity for high pressure and the worry over pressurized pipe ruptures and subsequent coolant loss that has plagued the operators of light-water reactors. This low pressure is a good thing because a ruptured sodium pipe would create quite a mess. Sodium bursts into brilliant yellow flame on contact with air.

The developers of the breeder in the United States, the AEC and industry (which is contributing to breeder research and development) justify the program for several reasons. First of all, the breeder will increase the energy available in uranium. Light-water reactors use U238 enriched with U235, and in the process of extracting the .7 percent of U235 that occurs naturally and concentrating it to 3 percent for fuel, much U238 is left unused. Massive stockpiles of "tailings" have been set aside, and these can be used as a fertile neutron acceptor. Also, because more plutonium will be produced than consumed by the breeders, plutonium can be used in light-water reactors. The cost of uranium is also considered. The AEC projects that low-cost uranium deposits are fairly limited and that the breeder could use high-cost deposits more efficiently. AEC's Division of Waste Management and Transportation Plans Branch chief Harvey Soule predicts that after about the year 2020, uranium will no longer have to be mined at all.

The need for additional fuel enrichment plants would be circumvented, and breeder proponents predict that electricity would be considerably cheaper than if produced with fossil fuels at their inflated costs toward the end of the century. Also, because the breeder would have a higher thermal efficiency, less hot-water pollution would be made per unit of electricity produced.

Explained in this way, the breeder sounds like a nearly perfect solution to man's energy problems. The AEC, while exploring other alternatives, has been operating under this premise for many years. The first breeder, an experimental reactor called Clementine, was developed at Los Alamos National Laboratory in 1946. The first electric power from a nuclear reactor was generated by the Experimental Breeder Reactor I, built near Arco, Idaho, in 1951. Two more test breeders, the Experimental Breeder Reactor II in Idaho, and the Enrico Fermi Atomic Power Plant on Lake Erie in Michigan,

have been in operation since the mid-1960's.

Encouraged by these programs, the AEC established the LMFBR program as its highest priority commercial reactor program. They reported this to President Johnson in 1967, and have been supported in their efforts by the Nixon Administration and the Joint Committee on Atomic Energy. A Fast Flux Test Facility is being finished now in Hanford, Wash., and will be used to test materials and fuels. Already in the beginning stages is the first prototype commercial breeder, the LMFBR Demonstration Plant, to be built along the Clinch River in Tennessee.

An environmental impact statement was issued on the demonstration plant in April, 1972. The AEC would not normally have issued another statement on the breeder program (subsequent statements will, of course, be made individually for each planned commercial breeder at its proposed site). But in 1971, the Scientists' Institute for Public Information brought suit against the AEC to force the publication of a statement on the impact of the breeder program in general. The U.S. Court of Appeals for the District of Columbia ordered last summer that the statement be written, and it is this draft which will be reviewed in the upcoming public hearings.

What the AEC has often failed to emphasize in its benefit projections are the hazards and risks associated with breeders. Breeder skeptics have lost no time zeroing in on these risks.

Two organizations, the Environmental Protection Agency (EPA) and the National Resources Defense Council (NRDC, a nonprofit organization of scientists and laymen based in Washington) reviewed the environmental impact statement issued in March. Both groups gave the statement a failing grade, and submitted to the AEC over a thousand pages of specific criticisms and suggestions. EPA's Director of the Office of Federal Activities, Sheldon Meyers, emphasized that the agency's criticisms were aimed at the statement itself, and not the LMFBR program in general. NRDC physicist Thomas Cochran openly states his position that the breeder is an unacceptable energy alternative.

Both groups object to the cost-benefit analysis used by the AEC to show the economic advantages the breeder affords and the necessity for funding the program at its present level. The analysis assumes that rising costs in other fuel technologies and for uranium will make the breeder favorably competitive and that an early introduction of commercial breeders is essential. The EPA says in its assessment that there are several methodological flaws such as the use of a low discount rate and certain capital cost estimates. Analysis with their methods show the breeder need not be pushed so quickly, and that there is time to "consider other uranium conserving technologies and . . . study and resolve some of the issues of environmental risk."

A major objection put forward by the NRDC is that the cost-benefit figures rely heavily on the projection of available low-cost uranium. They contend that the AEC is basing its projections on limited information about the total availability of low-cost deposits. "Their information," Cochran says, "is based on incomplete exploration of less than 10 percent of western uranium areas." NRDC calculations, admittedly crude, show at least 13 million tons of low cost uranium while the AEC projects only about .7 million.

The AEC in conjunction with the U.S. Bureau of Mines has begun a program to assess uranium resources nationwide, AEC economic analyst Saul Strauch says, and will have complete information in about 5 years. Questions remain in some minds about the sense of continuing the program at full speed before such an assessment is known, and about the original decision to support the breeder which was so heavily justified with cost-benefit figures based on future fuel reserves and prices.

Strauch says critics have failed to consider the importance of inflation in the cost-benefit picture. Greatly inflated coal and oil costs will make the breeder attractive regardless of the price per pound of uranium, he said.

Another major issue discussed in the EPA and NRDC assessments and publicly debated is the question of safeguards. Plutonium can also be used to make nuclear weapons. Criticisms have been leveled at the lack of safeguards now surrounding nuclear fuels during storage, shipment and use, and the attention paid this subject in the environmental draft statement. Many feel that growing world terrorism is an *a priori* reason not to make more potentially devastating materials available during the nuclear fuel cycle. Soule says the AEC is well aware of the safeguards issue, and is now discussing two possible solutions.

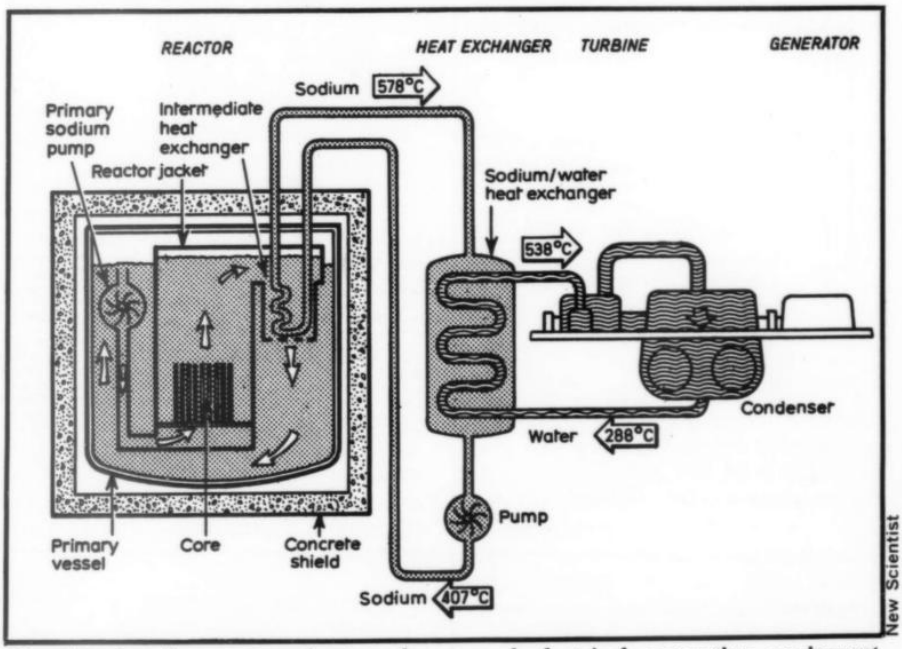
"There has been discussion of moving plutonium through the weapons transportation system, not the industrial transportation system. This is, of course, much more rigorous." In one sense, then, terrorists interested in stealing nuclear weapons materials could just as easily steal the whole weapon and not bother with handling radioactive materials.

"Another concept," Soule says, "is that of nuclear-energy centers. All aspects of the fuel cycle, fuel reprocessing, enrichment, the power plant itself, and the waste storage, would be located within one protected area. There would then be fewer inter-site shipments and elimination of the weak link in the cycle."

Cochran wonders who would want to live near one of these centers.

Besides plutonium's weapons potential, it is a highly toxic substance. If it were dispersed into the atmosphere by an accidental release or even through routine low-level emission, some think it could cause lung cancer. In its draft statement, the AEC acknowledges that little data are available on the health effects of plutonium. The EPA and NRDC stated that some projected risks should be included in the final draft statement so the breeder's full impact on public health can be assessed.

*Continued on Page 15*

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## . . . Crash

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Only two aircraft have been crashed so far, on Feb. 7 and May 8. These, plus a third scheduled for June 26, have been stripped-down vehicles without engines, tails, landing gear and other components, but with solid ballast replacing some of the parts and water in the fuel tanks, providing almost normal weight of about 6,000 pounds. Late in September the Army will step in with a super-crash of its own, a 30,000-pound CH-47 "Chinook" helicopter (with a full "crew" of nine dummies). After that, NASA will begin using its 20 complete aircraft, with 11 more stripped-down ones to be inserted at various points to test particular ideas or problems as they arise in the course of the program.

It is far too early for quantitative results to be available, and most of them will be in the form of numerical values to be used in fine-tuning subsequent computer simulations. Both NASA and the FAA agree, however, that even the first crash revealed what had been a widespread misconception in the limited studies of the past: "It was brought home to us loud and clear," says Langley's Robert Thomson, that there are two, not one, major impacts in a crash.

The assumption had been that a plane hitting the ground nose first gets one big jolt which is then transmitted rearward through the structure. The tests show that after the nose hits, the shock of the fuselage falling to earth behind it is a second substantial blow. At 60 miles per hour, says Thomson, the vertical loads in the second shock may be as high as 50 times the force of gravity, although they last for only two or three hundredths of a second.

The goals of the NASA and FAA research (the FAA will probably do its Atlantic City catapulting as the NASA data develop) are several. Most of the project officials at both agencies speak in terms of "developing the tool," meaning the computer analysis technique on which they must rely in the future when there are no flood-damaged airframes to throw around. It seems likely, however, that at some point the data will go into helping the FAA draw up more accurate, useful and rationally based safety standards for general aviation manufacturers. Improved safety would seem an almost certain result, although officials are reluctant to suggest that the program will result in anything that sounds like clamping down on the plane-builders. "Remember," goes the line, "it's not consumer testing."

True enough, but thanks to deadly Hurricane Agnes, the consumer—pilot and passenger alike—should benefit.

## . . . Breeders

Two more major issues have gained attention; the problem of radioactive waste storage and the uncertainty over reactor safety and potential accidents.

Many radioactive wastes (highly radioactive by-products produced during fission and fuel processing) will have to be stored for thousands of years before the radioactivity has died down completely. Some of the fission products are short-lived, but some, like plutonium, will emit neutrons for over 200,000 years. Breeder wastes essentially will not differ from other nuclear wastes, but there may be more of them, Soule said. The AEC is researching ways to store the wastes in stable geologic formations that have been undisturbed by seismographic activity for 200,000 years, which have not undergone any geologic changes in that time, and which do not drain into water tables.

"We are now investigating the possibilities of using dome salt formations, granite, limestone or shale deposits. Our criteria for choosing a site for geologic storage will be to find one where materials can be confined without maintenance indefinitely. It must be close enough to the surface to excavate and yet not so close that there are worries about people in the distant future wanting to get in to mine valuable minerals, or getting in by accident or erosion. The minerals we are investigating are so abundant, close to the surface, that it is hard to conceive of someone wanting to drill down 5,000 feet in order to get them out," Soule said.

In addition to researching long-term geologic storage, Soule outlined three proposed methods of retrievable surface interim storage. (Wastes would be stored on a short-term basis, perhaps 10 to 30 years, Soule said, until a suitable long-term method is chosen.) (1) Stainless steel basins filled with water inside reinforced concrete modular buildings could hold sealed canisters of hot wastes. This method is already being used in several locations. (2) The canisters could be sealed in concrete vaults designed with vents so that air enters at the bottom, cools the canister and rises by natural convection, carrying away the heat passively. "Where there is no electrically powered cooling system, there is none to conk out," Soule said. These vaults would sit on a paved surface in a guarded, enclosed area. (3) Wastes could be sealed in individual casks made of steel and concrete that would sit on a paved, guarded surface and be cooled by the air.

The EPA and NRDC assessments came down heavily on the AEC's waste-management proposals. The EPA is concerned that the reliability of current low-level waste storage has not been demonstrated, and that no long-term method is in sight. Cochran says, "We are 25 years into the nuclear age, and we have no permanent storage method, and the interim storage methods are unsatisfactory. There would be more radioactivity stored at one of these interim repositories than from a full scale nuclear war. A person could drive up to one in a van with a small nuclear weapon inside, or shoot one from a small cannon." If the weapon exploded and vaporized the canisters, the radioactive wastes would be carried up in a mushroom cloud and dumped all over the earth, he said.

The last major issue, reactor safety, is a complex one. Because the LMFBR would have a fast, unmoderated reaction, the time for safety systems to scram and shut down the reactor would be much shorter than for slow reactors. In a light-water reactor, there is no possibility of a nuclear explosion taking place, but a small one is possible in an LMFBR. The AEC says that the probability of the sequential accident factors necessary to bring on a nuclear explosion is tiny, and makes the event "extremely unlikely." The NRDC contends that such words are subjective, and that not enough solid data exist on the probability of an accident for realistic assessment of the risks to be made.

There are probably no right or wrong answers to the breeder issues—only degrees of confidence. The AEC demonstrates a traditional American "can-do" attitude. Whatever technological problems exist, they are convinced that the answers lie within the grasp of the scientific mind and the computer. And they have certainly overcome immense design and engineering problems in demonstrating the breeder thus far.

But Cochran feels they haven't come far enough. "They are more confident than I am about their computer codes, about their ability to fabricate equipment without flaws, about the possibility of operating the breeder without human failure, and about the backup and safeguards systems. I don't see the need for the breeder in the time frame they are projecting, and developing a technology before it is economically useful is a waste of money."

At this point, EPA plans to circumvent the upcoming public hearings, and instead, hold a series of meetings with the AEC to work out questions left unanswered in the environmental draft statement. After the meetings, Meyers said, "The AEC will have to decide what changes to make, if any. They don't have to do anything, but if they find our comments valid, we hope that they will alter some of the breeder plans in favor of the environment." □

# Globe trotting

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