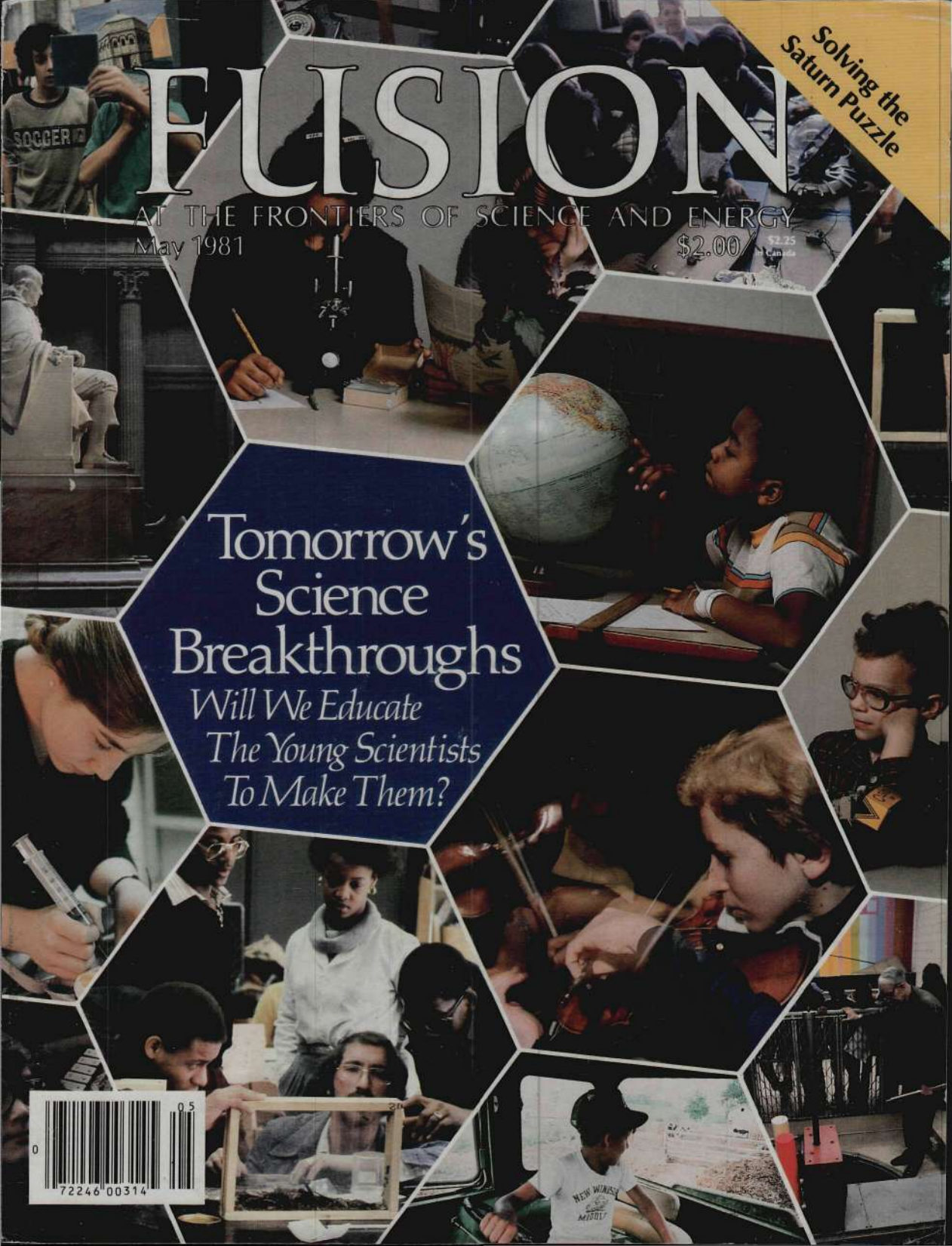
FUSION
AT THE FRONTIERS OF SCIENCE AND ENERGY
May 1981
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Tomorrow's Science Breakthroughs
Will We Educate The Young Scientists To Make Them?
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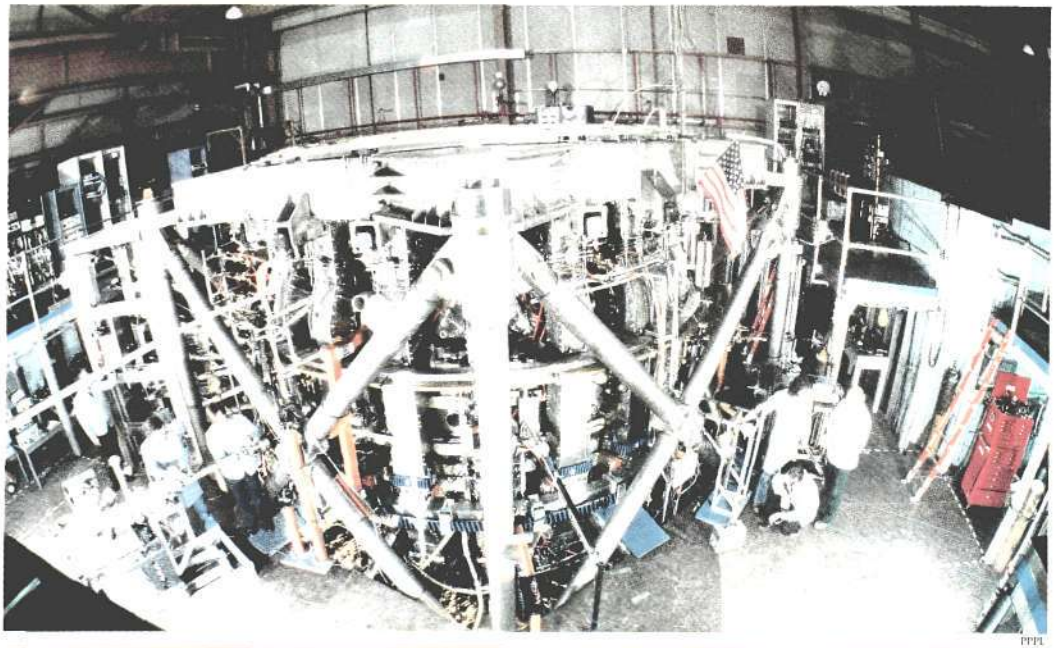

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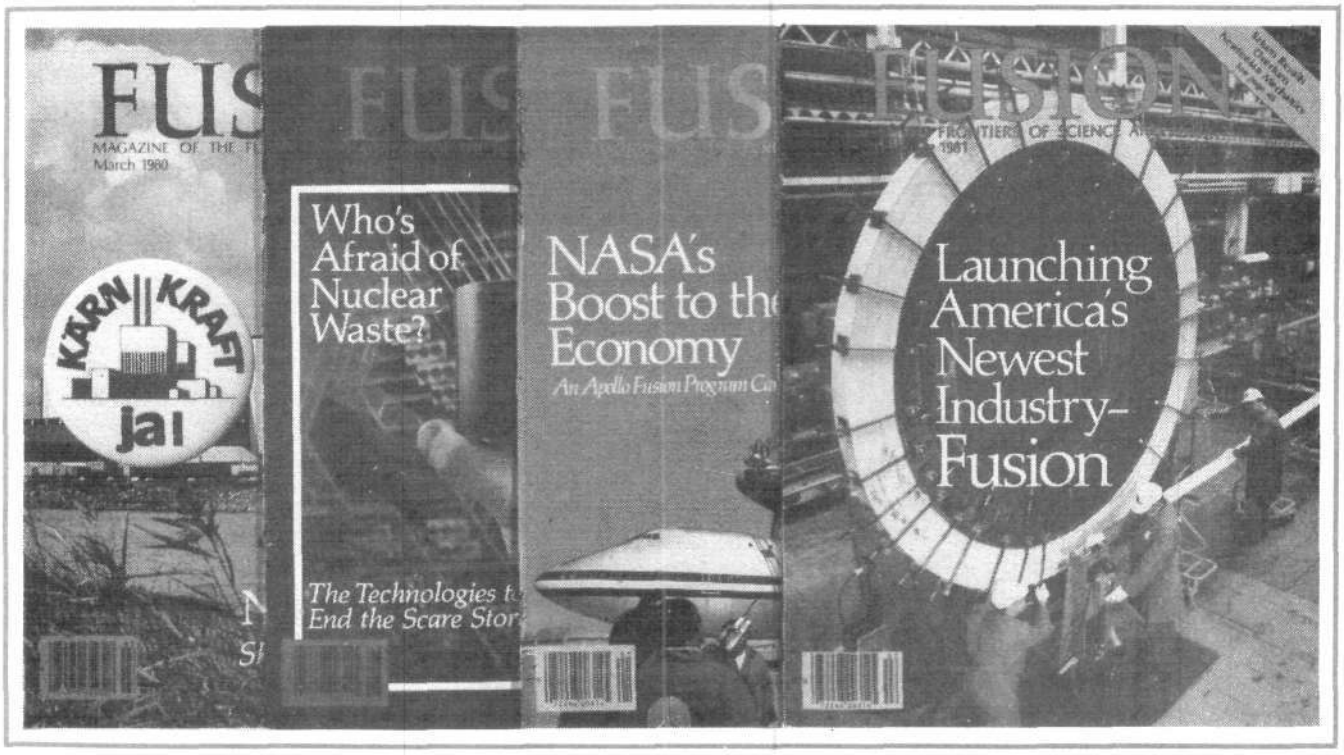

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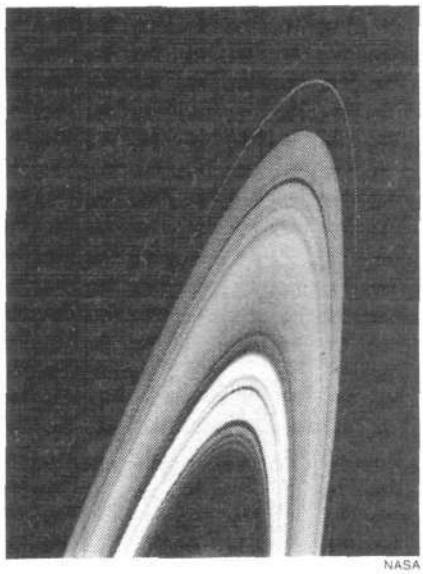
- Become a corporate or lifetime member of the FEF ($1,000).
- Sign up your friends and colleagues as members.
- Sponsor bulk subscriptions to *The Young Scientist* in your area's schools.
- Purchase the FEF slide show on fusion to educate your friends and community.

1980 was a year of progress for the FEF and the nation. With your continued support, we'll both do better in 1981. Contributions to the Fusion Energy Foundation are tax-deductible.

For more information, contact Harley Schlanger, FEF Membership Director,
888 Seventh Avenue, Suite 2404, New York, N.Y. 10019, (212) 265-3749.

*See *Fusion*, March-April, 1981, p. 37.



NASA

Saturn: The fabulous photographic data from the Voyager mission are a challenge to today's scientists and tomorrow's—a topic explored in this issue's editorial and the feature section.

Features

News

Henri Bureau/Sygma

"Fusion represents wisdom," says Michel Poniatowski, former French interior minister, in a wide-ranging interview on energy, science, and economics. His comments on the U.S. research situation are particularly interesting in light of the Reagan administration's budget decisions. See page 12.

Departments

From the Editor's Desk

Basic Science in Jeopardy

As we go to press, the Reagan administration plans to adopt research and scientific policies that will reduce the capability of the U.S. economy to grow. Alleging that there is a fixed budget pie, the budget cutters have set up two false dichotomies to justify their policies: near-term versus long-term research and basic versus applied science. The end result of these policies, however, is the same zero growth and deindustrialization advocated more directly by the Global 2000 proponents (see page 18). The implications of the proposed cuts for the fusion program are (1) that it will not be possible to begin implementing the engineering phase of the fusion program specified in the 1980 fusion legislation, which mandates the development of a fusion reactor by the year 2000, and (2) that the program will not have the kind of ongoing broad-based research that will permit the development of a commercial reactor (see page 41). The planned cuts in the space program, in science research, and in education will have similarly serious effects.

This budget policy is not only unfortunate but unnecessary. A broad-based R&D and basic science effort would take only a fraction of the revenues provided by a full gear-up of the U.S. nuclear industry to export technology, for example. Furthermore, delaying fusion or the space effort now will make it impossible to rebuild America's industry or to carry out any large-scale global development plan.

The FEF has launched a nationwide *science alert* to organize members, readers, and the majority of Americans who support science and technology to defend the nation's future by stopping these budget cuts. Call or write us for copies of the FEF policy statement on the science budget.

Marjorie Mazel Hecht

Marjorie Mazel Hecht
Managing Editor

FUSION
AT THE FRONTIERS OF SCIENCE AND ENERGY

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"ALL WE HAVE TO DO IS GET IT TO JUMP THROUGH THE FLAMING LOOPS!"

The Significance Of the Saturn Results

Much has been made in the press and in specialized scientific journals of the paradoxical nature of the Voyager observations. There can be little doubt that the pictures of the Saturn ring and satellite system radioed back to Earth by the Voyager spacecraft pose impossible problems of interpretation for prevailing theories of celestial mechanics. Such theories view the Saturn system as a complicated Newtonian *n*-body problem; that is, they insist that an explanation must be given in terms of interactions—gravitational and possibly electromagnetic—between a large but finite number (*n*) of independent bodies of different masses and composition.

The main paradox, however, lies in the fact that someone would attempt such a foolish *n*-body reduction of the Saturn problem in the first place, when there is a much superior scientific methodology available: the scientific tradition and the tried and tested results of the work of Kepler, Leibniz, Dirichlet, and Riemann. Kepler's comprehensive and rigorous approach—scientific rigor exists only when the question "why?" rather than the Aristotelian-Newtonian "what?" is posed—in uncovering the "why" of the workings of the solar system, an approach equally adequate and necessary in the analysis of the Jupiter or Saturn subsystems, was first demonstrated in his 1596 *Mysterium Cosmographicum* and developed in conclusive form in his last major work, the 1619 *Harmonices Mundi* (*Harmonies of the World*).

Kepler's Hypothesis

These two treatises are singled out rather than Kepler's writings on empirical astronomy, because these beautifully speculative works, often derided today as mystical numerology, so clearly reflect the essential character of his method.

In the *Mysterium,* Kepler put forward the following hypothesis concerning the relative sizes of the planetary orbits: that the observed quantitative sequence of the orbits is what it is, because it conforms to a unique succession among the five Platonic solids, the regular polyhedra. Specifically, if we take a sphere for the orbit of Saturn and inscribe a cube that, in turn, has been inscribed by a sphere, the latter will be the orbit sphere of Jupiter, and the remaining orbits are derived with reasonable accuracy, using the tetrahedron, octahedron, dodecahedron, and icosahedron in analogous fashion to the cube.

In the middle of the 18th century, Kepler's hypothesis about the regularity of the planetary orbits was improved upon by two German astronomers, Johann Daniel Titius and Johann Elbert Bode, who developed a quantitatively more accurate formulation known as the Titius-Bode law. Unfortunately, however, the Titius-Bode formula obscures the essentially geometrical and topological character of Kepler's original idea and makes its fundamental scientific implications much more difficult to recognize. Kepler, directly following Plato in this respect, asserted that the planetary orbits were *caused* to be what they are by a certain succession of regular polyhedra. For Arthur Koestler (in *The Sleepwalker*), such talk is proof of a deranged mind: "... Kepler's misguided belief in the five perfect bodies was not a passing fancy, but remained with him, in modified version, to the end of his life, showing all the symptoms of a paranoid delusion. . . ."

However, sticking to this *method* (which is much more important than the specific hypothesis in question) to the end of his life, Kepler laid the foundations of modern physics and astronomy; sticking to it with the same tenacity today will allow us to unravel the mysteries of the Saturnian system.

Viewed from the most advanced elaboration of the Platonic Keplerian standpoint to date, represented by the work of Bernhard Riemann, Kepler asserted the identity of the physical and geometrical features of physical processes as the basis for how the metric relations appropriate to that process are determined. In fact, this is the full meaning of the principle of relativity. It is the topological characteristics, such as the distribution of the singularities, the boundaries, and the overall connectivity of the manifold in question, which determine the "flow" of the physical geometry. Anyone who thinks that Kepler failed to develop rigorous mathematical analysis (which we are now able to access with ease as a result of the clarity and conceptual economy of Riemann's formulations in his 1854 essay "On the Hypotheses Upon Which Geometry Is Based") should read Kepler's wonderful little book *The Six-Cornered Snowflake*, which today would be classified as an advanced treatise in algebraic topology.

The investigation conducted there into the relations among the regular solids, the successful attempt at the generalization of the concept, and the identification of critical invariants were all conceived by him as an exploration of the mind of God the Creator. And by approximating an understanding of this mind he sought to discover the necessary form of the products of His creative activity.

We need not, of course, adopt Kepler's specific religious attitude or his specific scientific hypotheses, but the ontology and method must be the same.

In our corner of the universe, for specifiable reasons a hot gas cloud began a process of condensation, and this process of condensation and self-differentiation, under given boundary conditions, followed a definite pathway, evolving successively more complex and higher-order structures. The topology, geometry, and energy flows of such evolution are not arbitrary, but are governed by what might be termed a negentropic least-action principle, the type of principle which Leibniz, Plato's and Kepler's most gifted student, regarded as the essential characteristic of the physical universe.

The Saturn results thus present us with a twofold challenge: first, to look foward to the solution of the ever-new problems on the frontiers of physical science and second, to look back, so that we can use as our best guide the real history and conceptual basis of progress in mathematics and physical science, instead of the prevailing prejudices and mythologies on that subject.

The Lightning Rod

My dear friends,

I wish you could become better acquainted with my old associate, Richard Saunders, my collaborator in a printing venture some years ago and an inveterate maker of prognostications. Among the annual prophecies of *Poor Dick,* as he was wont to call himself (especially upon the presentation of a printer's bill from your humble servant), was a medical forecast *Of the DISEASES this Year,* to wit:

"The worst Disease of all will be a certain, most horrid, dreadful, malignant, catching, perverse and odious malady, almost epidemical, insomuch that many shall run Mad upon it; I quake for very Fear when I think on't; for I assure you very few will escape this Disease; which is called by the learned Albumazar *Lacko'mony.*"

It was the news that influential persons in the federal employ were discussing the possibility of cutting the *Fusion Budget* that alerted me to the probability that this "perverse and odious malady" had seized our new government in Washington.

When I made inquiries, I was told a Great Accounting had been done, whose results proved conclusively that *Monstrus deficitus* was growing on the Body Politick, sapping its strength; that a specialist had been called in to treat the affliction; that the good doctor has resolved upon a course of *even-handedness* in reducing the cancer; and that according to this principle, the Fusion Budget, as contributing to the affliction, must be cut.

Who is this learned medical man? I asked. I was informed that the famous Dr. Jefferson Heritage had consented to take the case.

"Heritage!" I exclaimed in dismay. "Why he is a notorious *bleeder,* and can be depended upon to reduce

Continued on page 6

Letters

The Question of Kepler

To the Editor:

The December issue of *Fusion* just arrived, and I would like to compliment you on your editorial regarding the complementary nature of space research and fusion research. It is a point we have been making for some time, arguing that all large-scale scientific efforts have common features that outweigh their detailed differences. Both space and fusion research act as stimulants and pacemakers for the development of technology. A strong space program is not possible without a healthy technology base, nor is a successful fusion program. . . .

The articles . . . were excellent, with the disturbing exception of Mr. Zubrin's comments on Kepler. To accept Kepler as a great scientist—of course; but to dismiss Newton's accomplishments as an "elementary schoolboy exercise," when the mathematicians of Europe had struggled with the derivation of an inverse square law and failed, is to say the least ingenuous.

The schoolboy exercise of today is yesterday's tough problem, and last week's epoch-making breakthrough. That's what scientific progress is all about. Newton abandoned causal problems in favor of action at a distance, absolute space, and absolute time for one reason: it allowed him to compute numerical results.

Isn't that what we want to be able to do in fusion research? If we had reliable and inexpensive ways of computing plasma behavior, I suspect we would be willing to tolerate a good deal of the "lowering of scientific outlook" that Mr. Zubrin regards as so reprehensible.

Charles Sheffield
President
American Astronautical Society
Alexandria, Va.

To the Editor:

I was impressed by the diversity of science articles in [the December issue of *Fusion*]. The article by one "Robert Zubrin" left me in a cold shock. . . .

If [Mr. Zubrin] is just an inspired scientist, rather than an established one, he seems to have a good grasp of Kepler. He also analyzes Kepler's work with a very sharp insight. It appears that his fine appreciation of scientific work by history's Great Men stops at that of Kepler's too. Please tell Mr. Zubrin that from Kepler's times till Newton the world had been endowed with a great many brilliant "elementary schoolboys" who simply did not attempt his famous "deduction . . . exercise," assuming he is right about this simple schoolboy matter . . . gravity.

If, however, . . . Mr. Zubrin is an accomplished scientist, I am amazed at his academic integrity which allows him to use such language and such sweeping assertions as "Newton contributed *absolutely nothing* to the understanding of planetary motion."

Peter Palutikof
Watertown, Mass.

The Editor Replies

The issue posed by Dr. Sheffield is a crucial one.

Newton's computational tools can, after the fact, describe many physical states of a process. But they cannot account for the lawful ordering prin-

The Lightning Rod

Continued from page 5

circulation until the patient is incapable of ingesting anything but large quantities of embalming fluid."

"But he has never failed to stabilize a patient," my source reproved.

I could not let this matter rest. "The Fusion Budget is an infinitesimal part of the total Accounting," I replied, "amounting to something less than *one-tenth of 1 percent*. Yet it promises unlimited Energy. Surely that would improve our economic Health."

"That is in the future," my interlocutor complained. "Now it is only a part of the *monstrus deficitus*, a small part to be sure, but according to the principle of even-handedness it must be cut."

I decided on another approach. "Scientific research is a developing Mental Power applied in the service of the Body Politick," I argued. "By cutting the Fusion Budget, you are cutting into the *Brain* of the patient."

"Dr. Heritage never makes concessions to special interests," he angrily replied. "He is against elitism, and believes in Democratic Decentralization."

"Even of the central nervous system? By that logic," I pointed out, "the Dinosaur was superior to man, as it is said that he had a second Brain at the base of his Tail."

"Two heads are better than one," my acquaintance rejoined.

"But not on the same person. Unless, of course, he is the editor of a liberal newspaper, in which case the condition is known as pluralism and is regarded as indispensable for his functioning."

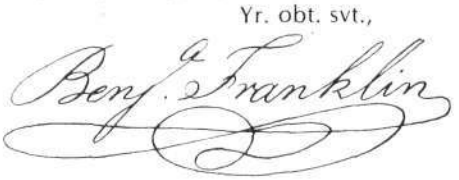
My informant was again incensed. "Dr. Heritage will have nothing to do with liberals," he stressed. "He is a most *conservative* doctor, except when it comes to *radical surgery*."

"Well if the good doctor is determined to cut something," said I, "let him cut the cost of money, which is so frightfully dear. I am told each 1 percent increase in the prime interest rate increases the *monstrus deficitus* by $2 billion."

"Alas, no," my acquaintance said. "The opinion of Dr. Jefferson Heritage is that the cost of money is the one thing that may not be cut. You see," he continued, "the reason money costs so much is that it is the one thing everyone wants. That is the law of supply and demand which on no account may we interfere with."

By this time I had determined that urgent communication with you was absolutely required, in the interests of restraining the mad Dr. Heritage before serious damage is done. Together let us do what we can to keep the President and the Congress safe from his ministrations.

Yr. obt. svt.,



ciples of the phenomena they describe, or the succession of physical geometries.

The difficulties that arise from this are plain enough in the inability of Newtonian equations to adequately describe a so-called three-body interaction. The same problem is demonstrated in the case of the recent results of the Voyager 1 fly-by of Saturn, and in the theoretical impasse in inertial fusion work. We refer you to Dr. Steven Bardwell's "Solving the Three-Body Problem" (*Fusion*, June 1978) and "The Theoretical Impasse in Inertial Confinement Fusion" by Uwe Parpart (*Fusion*, Nov. 1979).

Kepler's approach, however, proceeds from a more advanced standpoint—the relativistic physics of the system as a whole.

Dr. Morris Levitt
Editor-in-chief

Kepler's Debt to Gilbert

To the Editor:

Robert Zubrin's review of the method which underlay Kepler's astrophysical discoveries will undoubtedly prove painful to those historians of science who, like Arthur Koestler, ascribe Kepler's geometrical intuition to some sort of mysticism, rather than the Neoplatonic tradition in which he was rooted. Three cheers for that!

One aspect of the story, however, was not treated in its actual significance—the seminal role of the English physicist and physician William Gilbert.

Zubrin comments that "Kepler followed Gilbert in the wrong supposition that [the force organizing the heavenly motions] was magnetic." True enough, but the crucial point is that Kepler followed Gilbert in the *right* supposition that "all the manifold motions are taken care of by one single absolutely simple bodily force." Kepler was straightforward in acknowledging his debt to Gilbert, since Gilbert was an international leader of the Platonic scientific faction to which he belonged.

Gilbert's experimental work—reported in 1600 in his *On the Magnet*—was the first systematic treatment of a field phenomenon, including the effect of the magnetic field on the plasma of a candle's flame. He demonstrated how the method of hypothesis could be used to guide experimental discoveries, and he mounted repeated and sophisticated polemics against the Aristotelian materialist tradition in the sciences.

Gilbert's importance is summed up in the fact that he is almost totally unknown today to working scientists and the educated population at large. He was plunged into this obscurity through the efforts of his enemy Francis Bacon, who launched a campaign of slander and vilification after Gilbert's death. Bacon, who updated the Aristotelian materialist categories in his *Organon*, ridiculed Gilbert's precise experimental work in order to reduce the influence of Gilbert's scientific circle, inasmuch as this circle was heir to the political-scientific faction of John Dee and the Earl of Leicester, which had planned Tudor England's republican thrust for colonization of the New World.

Britain's Royal Society, modeled on Bacon's *New Atlantis* and committed to the empiricist methods of his *Organon*'s silly experiments, continued the slander for the same political factional advantage. That this was at least partially understood in the United States during the last century is made clear by the relative treatment given to Gilbert and the Royal Society in *The Intellectual Rise in Electricity* by Park Benjamin (New York: 1895), itself an American factional document against the reign of British empiricist science.

Gilbert's work was enthused with the epistemological standpoint of the Neoplatonic Renaissance, the tradition of Nicholas of Cusa, Dante, and Giordano Bruno. He most likely knew Bruno in England, and his conceptual borrowings from Bruno are obvious in *On the Magnet*. Gilbert used the word "virtue" (*virtù*), which had been used by Renaissance thinkers beginning with Dante and later Machiavelli to signify the quality or force of creative intellect and will, to represent the magnetic field phenomena he was studying, and Kepler followed suit in his description of the gravitational field of the planetary system.

Thus, clearing up the historical record concerning Gilbert is important precisely because it makes totally un-

tenable the myth that the scientific fraud Francis Bacon was the "initiator of modern science," as he is often described by many misinformed people. Since Zubrin's article was aimed against the Bacon-Newton history of scientific perversion (and plain perversion), there was certainly no intention to peddle the same line against Gilbert that the Newtonians have consistently used against Kepler.

Kenneth Kronberg
New York City

To the Editor:

Having read . . . "Kepler and the Harmony of the Spheres," I wish to read the "recent theoretical work" and any modern work on this subject. But you gave no references. . . .

Louis P. Kerpan
Surrey, B.C., Canada

The Author Replies

Some of the recent theoretical and experimental work demonstrating the "harmonic" or self-organizing properties of matter on an astronomical scale is discussed in the Dec. 1980 *Fusion* features on the magnetic structure of the Sun, supernovas, and shock waves in cosmology. Dr. Schoonover's article on Saturn in the present issue is also relevant.

For a necessary fundamental background in the negentropic nature of matter in general and plasma physics in particular, see the articles by Dr. Steven Bardwell, "Elementary Plasma Physics from an Advanced Standpoint" (*Fusion*, Nov. 1978) and "Electron Transport in Tokamaks: A Case Study in Negentropy" (*Fusion*, Sept. 1979). The next issue of the *International Journal of Fusion Energy*, also available from the FEF, carries a review of recent work on gas flows at various velocities, showing that the tendency is for large-scale vortical structures to form on all levels, superseding the apparent randomness for any individual particle.

Robert Zubrin

'Chic' Fusion

To the Editor:

I recently purchased the Jan. 1981 issue of *Omni* magazine, the "chic" science publication, which had devoted that issue to a discussion of fusion. . . .

The [article] "Fusion Politics" by Daniel Greenberg astounded me. It managed to trace the past 10 years of political and scientific debate around fusion leading up to the McCormack fusion bill without once mentioning the Fusion Energy Foundation. That is an accomplishment equivalent to outlining the scientific history of fusion without mentioning the Soviets and the original tokamak!

I am far more questioning of the interview with Robert Bussard, the well-known physicist. While I tend to be suspicious of any "advocate of the small-is-better school," the man's credentials are quite impressive. In addition, there seems to me to be no inherent, obvious facileness in his advocacy of a small "throw away" modular fusion reactor design. . . .

As far as can be recalled *Fusion* magazine has never delved into the merits of Bussard's Riggatron device. Is Bussard spewing forth merely hot air or is it potentially an energy-rich hot plasma?

Ronald M. Castonguay
Nashville, Tenn.

To the Editor:

I have depended on *Fusion* to keep me up-to-date on the developments in fusion since the beginning of the publication of the magazine.

Imagine my surprise when in the Jan. 1981 issue of *Omni* I read about work on the Riggatron by Inesco and work on the Ohte by Dr. Tihiro Ohkawa.

Why have I read nothing on these in *Fusion*? They appear to offer a quicker way to *fusion now*.

Frank E. Rickel
Pittsburgh, Pa.

The Editor Replies

The Aug. 1978 issue of *Fusion* (p. 51) in "Is the Riggatron Case Rigged?" reviewed the political and scientific questions involved in the Bussard Riggatron proposal.

Long before this, *Fusion* had covered in detail the scientific concepts upon which Bussard based his particular approach to developing a high-magnetic-field tokamak. These concepts were originally the work of Dr. Bruno Coppi, the scientific genius behind the success of the MIT high-field Alcator tokamak. Coppi's paper laying the basis for this general approach to fusion, "Compact Experiments for Alpha-Particle Heating" [PRR Report, 76, 31 (1976)], and its implications for developing a "throwaway reactor" were discussed in the Dec. 1977-Jan. 1978 issue of *Fusion* (p. 32):

"Coppi's basic idea is to go for broke on high magnetic fields, pushing the technology as far as conceivable. With innovative concepts, fusion temperatures could be obtained. . . . If the Coppi experiment is modestly successful, one speculation is that high power density reactors, possibly just for breeding fission fuel, could be built rapidly. The reactor core that deteriorates in the fusion environment, because it is so small and cheap, could be replaced every year or so—the throwaway reactor."

As for Dr. Ohkawa's Ohte (which *Omni* fallaciously reports as an experiment in his garage!), *Fusion* has not reported on this device because it has not yet operated, and the Ohte concept has until recently been considered a proprietary concept, privately developed by General Atomic. Thus details are not available in the scientific literature.

Note that *Omni* in no way describes how the Ohte is supposed to work, even in simple terms. The general scientific basis for the Ohte is directly related to work on field-reversed toroidal pinches. In fact, the Ohte is called a reversed pinch by its inventors. The growing success of research along this general line is reviewed in the Jan. 1980 issue of *Fusion*, "The Zeta Moves into First Place in Fusion."

See the Science Press Review in this issue for further comment on the *Omni* fusion articles.

Charles B. Stevens
Fusion Technology Editor

RARE II Goes to Trial

To the Editor:

I was disappointed that William Engdahl's Dec. 1980 column on the Department of Agriculture's RARE II study was rife with errors. . . . Engdahl also cites the Eastern Wilderness Act as providing that "only Congress, not

Continued on page 62

Viewpoint

Fusion Is 'Achievable'

by Dr. Melvin B. Gottlieb

Editor's note: Dr. Gottlieb's viewpoint is excerpted from his remarks at a press conference Feb. 6 at FEF headquarters. The discussion with the press preceded the banquet sponsored by the FEF in honor of Gottlieb's retirement as director of the Princeton Plasma Physics Laboratory. *See page 47 for a report on the banquet.*

Is the fusion program amenable to tradeoffs of one program for another for budget cuts? Not very much, although some of this could be done. You could decide to narrow the efforts. In my view, however, this would be extremely premature and would represent a diversion. One could say that the system that is farthest ahead, the tokamak, should be the focus—"let's put all our eggs in that basket." But we're not ready for such a step. It would be a serious error.

You could simply insert delay into the program, do all the things already under way in the program, just do them slower. This would also have a very serious effect.

We have many very good and well-trained people. I have seen them develop over the years. They are now fully engaged, and we have begun to engage industry as well. The people in industry have their own skills, but those skills must be fine tuned. It takes a period of training before these people are indeed useful, as they now are. To disengage them at the present time would dissipate those efforts that have already been made. These trained people would move to other activities, would no longer be available.

There is also the effort required to get into technology. Certainly there are many things required for a successful fusion reactor. One among them is, of course, the physical aspect of being able to heat a gas to a high enough temperature and keep heat losses to a sufficiently low level. That is certainly one requisite. But it alone doesn't build you a power reactor. It gives you a solution of some very interesting physical problems, but to that must be added a great deal of work on the engineering and technological aspects. These must be resolved, in addition to the physics problems, before you have a practical reactor.

We are just getting into that phase where we can at least get a plasma or hot gas under conditions very similar to those that will exist inside a fusion reactor, and now start to engage the technological questions that must be solved and try out these solutions in an apparatus that has this hot plasma within it.

This is a field in which the technology and the science are so interdependent that they must be developed together. . . .

We now have confidence that the tokamak can produce a thermonuclear plasma with a density, temperature, and containment time high enough to represent a demonstration that a reactor can be built. But that's not sufficient for a practical reactor. For a practical reactor you must make sure that you have a device simple enough and cheap enough. Economics are basic.

It is quite clear that the tokamak itself can be improved substantially, in economic terms. The present tokamak has, in a sense, given us the easiest path. At times it has shown us solutions that we didn't know existed, providing us with a somewhat simplified road. It is important now to explore the adjacent possibilities and other methods, and see which one is really best. That is why a broad program is important. That is why I supported the mirror program even when it was under strong attack in the past. . . .

There are substantial improvements that can be made in the tokamak, many modifications that might in the end prove simpler, or cheaper, or more reliable. And there are different approaches like the mirror, or hybrids between the two—for example, the Elmo Bumpy Torus, which is a sequence of mirrors, arranged around a ring. These take time to work out. And unfortunately, this research is not cheap. . . .

Ten or fifteen years ago, fusion energy seemed almost impossible. We were frustrated. But then everything started to work, probably because of better control of the technology, at the same time that we got better control over the physical ideas. There was a turnabout. Now, I feel sure that it is achievable. I can't tell you what the costs will be, for that still has to be worked out. We have to get the costs down to where fusion will be competitive. Here, too, I have no doubt that it can be done. . . .

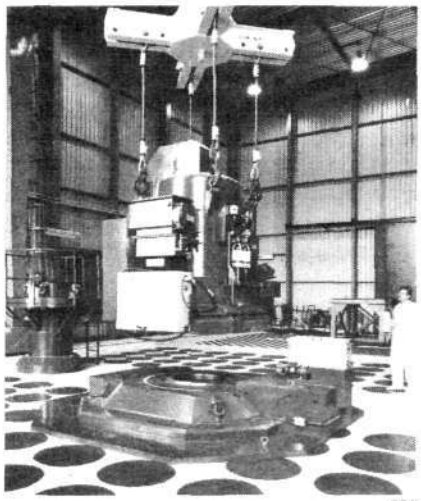
The change, I can only describe this way. Back in the beginning, the theorists were working in one place, the experimentalists in another, and it almost seemed as if they weren't even speaking to each other, in the sense that what you saw in the laboratory bore little relationship to what the theorists were discussing.

Now, both are addressing the same points. In other words, it's gone from a very exploratory stage to a solid science. It's that change which has made the real difference.

One can now talk even about new ideas with confidence: ideas that involve much closer control of the plasma. We can even hope that these very simplified forms—which are tremendously sophisticated from a scientific standpoint, but very simple from an engineering standpoint—will work.

It is as different as day and night. That is the change of the last years.

News Briefs



CEA

France leads the world in nuclear technology. Here the nuclear waste vitrification plant at Marcoule.

FRANCE SIGNS NUCLEAR TECHNOLOGY DEAL WITH EGYPT

France and Egypt signed a nuclear cooperation agreement in Paris Feb. 12 under which France will begin supplying Egypt with nuclear power stations, fuel, and technology. French Foreign Minister Jean François-Poncet said after the signing ceremony that the details of the agreement still have to be hammered out, but that it will involve the sale of two 1,000-megawatt nuclear reactors. The Egyptian government currently has plans to build eight nuclear power generating stations by the year 2000.

The French-Egyptian agreement is only one of a series of nuclear deals that the French government is arranging with, to date, five African countries. The most ambitious of these involves Morocco, with which France has signed an agreement to supply a nuclear reactor by the mid-1990s and to help develop a major national uranium industry. Another target of French nuclear export diplomacy is oil-rich Nigeria, whose foreign minister came to France in late January to discuss a broad array of trade deals including an oil-for-nuclear exchange.

S. KOREA HOPING FOR U.S. NUCLEAR EXPORTS

During his trip to the United States in January, South Korean President Chun Doo Hwan informed President Reagan of his country's ambitious nuclear program, based on a proposal by the Korean Institute of Science and Technology for a $100 billion plan to build 110 nuclear reactors by the year 2020, 46 of them by the year 2000.

South Korea now has nine nuclear plants either completed or under construction. Its new construction plans additionally call for the development of the fast breeder, without which nuclear fuel would become too expensive, the South Korean report states. The report also criticizes the United States and the Soviet Union for attempting to deny this critical technology to developing nations like South Korea.

The final communiqué issued after the Chun-Reagan talks stated that "President Reagan promised that the United States would remain a reliable supplier of nuclear fuel, generation equipment, and power technology." The South Koreans are reportedly hopeful that the new administration in Washington will reverse the Carter administration's disruptive policies on nuclear exports, which lost Westinghouse Electric millions of dollars worth of contracts to France's Framatome during 1980.

HITACHI DEVELOPING NUCLEAR REACTORS FOR EXPORT

Hitachi, Ltd. of Japan disclosed in January that it embarked on a program last fall to develop a 200,000-kilowatt boiling water type nuclear reactor (BWR) for export. This makes Hitachi the first Japanese manufacturer of nuclear reactors to begin developing a model for export; thus far the international nuclear reactor market has been exclusively dominated by American and European reactor manufacturers.

Japanese sources indicate that Japan's Ministry of Trade and Industry (MITI) and its Foreign Ministry are reviewing international nuclear export regulations and readying themselves to fully back up Hitachi's new export efforts from the standpoint of promoting economic cooperation between Japan and developing nations. The prospective export destinations under consideration for the small-size, compact reactor model are Singapore and other Southeast Asian countries, China, and Latin America.

Sylvain Julienne/Sygma

ETA terrorists in training: "A murderous fury" against progress.

NUCLEAR ENGINEER ASSASSINATED BY ETA TERRORISTS

Despite widespread outrage in Spain over the assassination of the chief engineer of Iberduero's Lemoniz nuclear plant by a Basque terrorist group, the Spanish utility company has announced that it is delaying construction on the plant out of fear for the lives of other employees.

The assassination of José Maria Ryan, 39, marked a bloody escalation in the violence that ETA terrorists have used to halt construction on the Lemoniz plant. Iberduero has invested $1.5 billion in the plant since construction began in Aug. 1972. Lemoniz 1, a 1,000-megawatt unit is 90 to 95 percent completed

and was expected to begin commercial operation by the end of 1981; the second 1,000-megawatt unit is 25 percent completed and was scheduled to be operational in three years. The ETA terrorists gave Iberduero one week to shut down and begin dismantling the plant in return for the release of Ryan, who was kidnapped Jan. 29.

The response to the murder of the engineer and other acts of terrorism by ETA was a general strike throughout the Basque country. Even the Basque Nationalist Party, of which ETA was an offshoot, came out with strong denunciations of ETA's terror campaign. Party leader Juan José Pujama called the killing "a murderous fury that must be eradicated."

LOPEZ, GANDHI PLEDGE FIGHT FOR ECONOMIC DEVELOPMENT

Mexican President José López Portillo concluded a historic six-day visit to India in late January with an affirmation that the two nations will assume leadership roles in the battle for global economic development over the coming months. López Portillo told reporters at the conclusion of his visit that his discussions with Indian Prime Minister Indira Gandhi had covered "all aspects" of multilateral and bilateral issues, taking up such topics as the necessity to renew North-South talks on technology transfer and India's success in achieving self-sufficiency in grain production using high-yield wheat varieties imported from Mexico.

Paying tribute to India's commitment to progress, López Portillo declared: "We have been greatly impressed by the conjunction of India's great past with its exemplary development efforts. We have seen the temple caves carved out of the rocks in Aurangabad [dating from the second century B.C.], the Taj Mahal, and also its efforts to develop nuclear energy, all of which are very representative of this great nation."

Courtesy of the Government of India

Gandhi and Lopez Portillo: A pledge for transfer of high technology.

LIFE-SAVING MEDICAL TECHNOLOGY UNDER ATTACK

Investigators at the Duke University School of Medicine, led by Dr. Robert Gutman, have published preliminary results that maintain that more than 50 percent of the patients receiving dialysis, a life-saving treatment for people with failing kidneys, are too sick to function in a normal manner. The figures in the report, which was published in the Feb. 6 *New England Journal of Medicine,* have been challenged by other researchers such as Dr. Freeman of the National Kidney Foundation. He reported that at the medical institution where he practices, "We've never had as many as 20 percent who are severely debilitated."

The Duke study, however, has resulted in a renewal of the attacks on the use of dialysis machines for kidney failure patients and high-technology medicine generally—bone transplants, heart transplants, and other revolutionary techniques that some consider too great a drain on society's resources. Roger W. Evans, a researcher at the Batelle Human Affairs Research Center in Seattle and a student of health care triage, suggests that the United States look to England as a model for the rationing of health care. There, patients are generally denied access to dialysis and other advanced medical treatment because they are over 65, and health care expenditures are thereby held down.

MAY LOUSEWORT LAURELS: LET 'EM EAT GRAIN

This month's lousewort award goes to David Pimentel of Cornell University and Alex Herschaft of the Mitre Corporation for their presentations at the annual AAAS meeting Jan. 4 in Toronto arguing that the problems of energy, raw material scarcity, pollution, and health all could be solved if Americans would stop eating meat. Pimentel, an agricultural economist, claimed that the United States would realize a savings of 75 percent in energy inputs if Americans would switch to grain consumption for protein intake, because meat production is so "energy inefficient." Meat production, Herschaft said, consumes 14 percent of all energy consumed.

The award winners also claimed that cutting down on meat and dairy consumption will "improve" the nation's health.

An Interview with Michel Poniatowski

At the Frontiers of a 'Scientific Civilization'

An influential voice in French politics, Michel Poniatowski is director of the Institut de Prospectives, a private think tank engaged in the study of advanced technologies and the problems of future civilization, which he founded. Poniatowski was minister of the interior in the government of Giscard d'Estaing from 1974 to 1977, and he continues to be a close political ally of the French president, serving as Giscard's ambassador without portfolio. Poniatowski toured the U.S. national fusion laboratories in spring 1980 in the interests of his institute.

In December 1980, Poniatowski was interviewed in Paris by Dana Sloan, a frequent contributor to Fusion, *and Philip Golub, who works with the Fusion Energy Foundation in Europe. The policy questions raised here, particularly the role of nuclear energy in the Third World, will be discussed in the next two issues of* Fusion.

Question: You have often referred to different scientific and technological breakthroughs, in particular to thermonuclear fusion power, as holding out the promise of a future free of energy constraints. Could you elaborate on this?

Fusion, quite simply, represents wisdom.

Known uranium resources are limited. If between now and 1985-1990 we actually put on line the 400 nuclear power plants that theoretically are scheduled, including the 200 or so that are now functioning, then by 1990, with known uranium resources what they are, we will have about a 20-year reserve. In other words, we will have the same problem with uranium that we now have with oil.

Then there is the fast breeder reactor. The advantage of the fast breeder is that it multiplies 60-fold the value of those reserves. France has known uranium resources in Brittany, in Auvergne, and in other places

"For us in France the problem is a simple one. We are absolutely obliged to launch ourselves into a nuclear program, even if this does not please everyone."

that represent about 20 years' worth of fuel supply for ordinary nuclear plants. If these resources are applied to the fast breeder, they represent reserves of about 1,200 years, not 20. This is why we in France have committed ourselves to a fast breeder program. The first reactor will be built at Creys-Malville and will begin operating toward the end of 1983.

In the nuclear field, and as long as we have not found other forms of energy, the fast breeder is our only future because it completely alters the problem of necessary mineral reserves. Without the fast breeder, nuclear will end up being like oil.

Question: What are the prospects in the field of fusion energy?

We are carrying out research and studies in France, and what I saw in the United States seems quite advanced. I think that in the next few years—it is always very unwise to give figures, even though the American experts I met gave me figures—we will achieve experimental results. You know that it is a question of achieving a certain temperature, 100 million degrees, in a continuous manner, that creates the conditions for fusion. From the experiments now being conducted, I understand that in the next three to four years fusion reaction will be achieved in the range of 100 million degrees. But to go to the industrial stage it will probably take an additional 20 years. And we must also ask ourselves which is the best method, because there are several: laser beams, the magnetic system, and possibly other methods if the laser and magnetic systems prove to be unsatisfactory.

In other words, we are probably very close to the scientific experience of fusion, but the industrial implementation is still a bit farther down the line, by about 20 or 25 years. In any case, this is the impression I have received from all the meetings I have had with American experts and also with French and German experts.

Question: After your recent visit to the United States, do you think effective collaboration can take place between France and the United States?

I think that this is very desirable, and I think, I hope, that in the framework that will be opened by the new Reagan administration, such collaboration will be possible. I must tell you that when I visited the United States last March, I was very much struck by the fact that people were extremely discouraged. I found scientists and experts who had the impression that their work could not lead to results in terms of its economic realization. They had the impression that politics were preventing them from realizing economic breakthroughs that to them appeared absolutely indispensable—and that are absolutely indispensable. I would almost say that people felt humiliated, humiliated because they could not do their job as they knew they must.

The United States is a country that I like very much; I came to know it well when I was stationed at the French Embassy in Washington. One of the things that has struck me, particularly in the last few years, is that although you have remarkable people in many fields—whether industry, scientific research, university education, banking, and so on—the political domain is not marked by such a display of qualities. It is not always necessary

for people in the political world to be brilliantly intelligent, but they do have to be able to determine what are the real problems of the future. They do not have to know everything, but they do have to know how to choose their advisors for each essential area. During the trip I took last March, I was struck by the degree of discouragement felt in many areas, because people had the impression that politics were paralyzing what was necessary to do for the future of the country.

Question: Given the considerable efforts that the Soviet Union has devoted to fusion research, do you think that Soviet-Western collaboration in this field is possible?

This is a question that should be posed to the United States. Before the tensions unleashed by the Afghanistan affair—in which, by occupying that country, the Soviets carried out an operation that was politically inadmissible—the United States and the Soviet Union had very advanced scientific relations. You must not forget that there were 120 joint Soviet-American working commissions in all major areas, and in particular in energy-related areas, and there was a commission concerned with fusion energy in which information was being exchanged.

But to really answer your question: One can think of the planet in many different ways. One can think of it in political terms, in other words, in terms of a confrontation between the liberal world and the Marxist world. One can think of it in geographic terms. But there is a way of looking at it that people don't generally think of, but that they will more and more because it will impose itself. It is that the industrially advanced countries form a community, and this community is made up of the Soviet Union, the two Europes, the United States, Canada, Japan, Australia, and South Africa. And these countries form a community of countries that are industrially, technologically, and scientifically advanced, and that, leaving aside Japan, are countries of the same religion, of the same cultural origin, which is Latin-Greek, of the same

Nogues/Sygma

Michel Poniatowski (left) greets West German Chancellor Schmidt, as French President Giscard looks on.

race—no one dares to use this word anymore, but it's the truth—and this world is already quite welded together. The countries are differentiated by many things—by competition in industry, in production, and so on—but fundamentally these are countries tied to each other. Already 60 percent of industrial trade takes place among them; it is only the remaining 40 percent that is sought elsewhere in the form of raw materials and energy. And in my opinion, if we don't have a war, this meshing will continue to develop even further.

Of course, we can do what Europe did in 1914, which is to have a civil war. Europe was the great power of the world. It was the great financial power, and the great scientific and technological power. These were the countries that were colonizing the rest of the world in Africa, Asia, and Latin America. And then the European countries carried out the abominable crime of making a civil war against each other. The countries of the advanced industrial world today could also commit this crime of making war against each other.

Question: Nuclear war?

Yes, it could be a nuclear war. At any rate, the European countries could find themselves in conditions that would lead them to a real civil war in the advanced world. But if they don't come to war, when countries are not making war, they are talking to each other, they are developing their relations, they are developing their trade, they interpenetrate more and more, and I think that this is what will happen in the advanced world. In any case, we will have the answer very soon, because either we will have a conflict in the four or five years to come, or we will have more and more marked interpenetration. In this respect, the advanced world will become really international, because everything that occurs in one country will necessarily have repercussions in another.

It is already happening now. When the Japanese make a breakthrough in robotics, the Americans follow as quickly as they can, and we Europeans follow after the Americans. All scientific breakthroughs—such as a breakthrough in fusion—will necessarily become international breakthroughs very rapidly. It is like what happened in robotics. In Japan, the first robot

arrived in 1968. It was an American robot. The Japanese copied it, they improved it, and they invented their own robot. Now they are four or five years in advance, and the Americans are running after them. But since the Americans are starting later, they will end up with the most refined, the most advanced models.

In Europe, everyone is very worried about the Japanese; however, this is a mistake. We should be worried about the following phase, which is the American phase, because there will also be a political aspect to it; namely, that we cannot carry out protectionism against the Americans.

Question: Can the French nuclear program, which includes the fast breeder and a complete nuclear fuel cycle, serve as a model for the industrialized countries?

This question brings us back to the problem of resources. The countries that do not build fast breeders will not multiply their resources. And I would almost say that it makes no sense to build nuclear reactors, if you don't also build breeders that reuse the materials that were used a first time in the nuclear plant and that multiply by 60 the value of available resources. Any nuclear program must naturally lead to a fast breeder program.

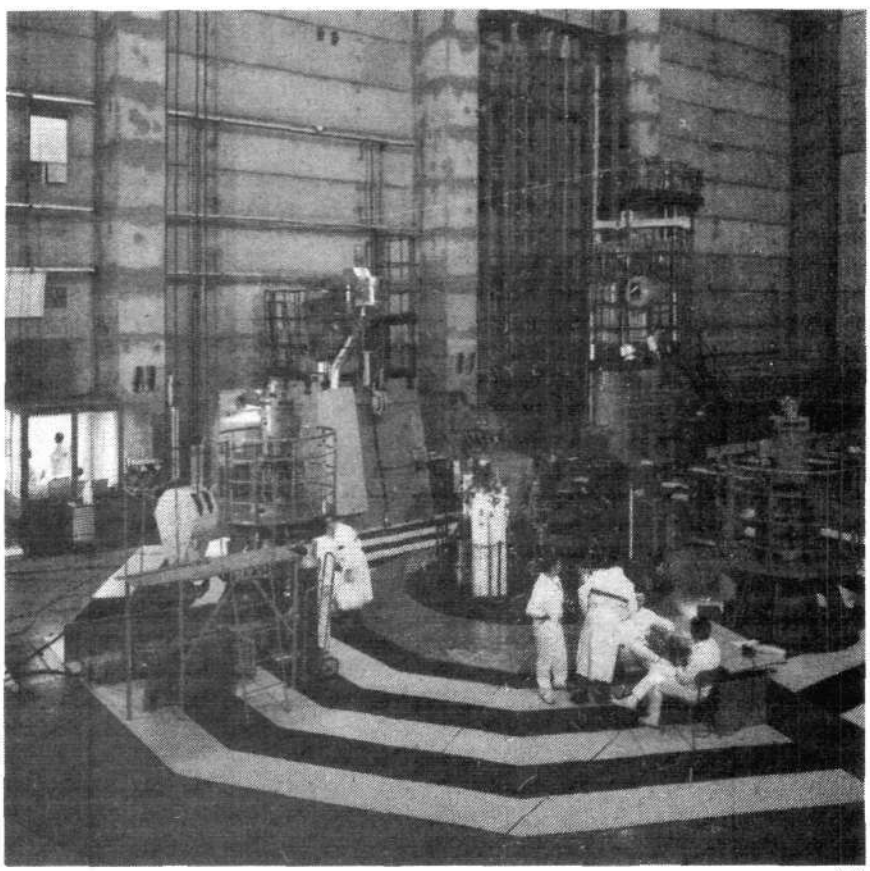
Question: The oil price increases have shown the developing-sector countries to be vulnerable and shown that only the transfer of advanced technologies can guarantee their energy independence and economic survival. What role can nuclear energy play in the transfer of technology?

Your first premise is exactly right. Because of the oil crisis, we are confronted with a sort of blockage of the economies of a number of developing-sector countries. The projections for 1980 are that the balance of payments of the oil-producing countries will be in surplus by $120 billion, while the developing-sector countries will run a balance of payments deficit on the order of $75 to $80 billion. The OECD [Organization for Economic Cooperation and Development] countries will have a $40 to $45 billion deficit, which will be partially offset with other receipts, what we call the "invisibles," but the OECD countries will still be in deficit. The developing-sector countries will have to sustain their additional $75 to $80 billion deficit on top of their existing indebtedness, which at the beginning of 1980 was on the order of $300 billion. So at the end of 1980, the developing-sector countries will find themselves with a deficit somewhere between $375 and $400 billion, with about 20 countries in a state of absolute bankruptcy. To a large extent, this situation is the result of the oil crisis.

Is nuclear energy the answer? Nuclear energy is very expensive. It is not very expensive to consume, since the kilowatt-hour cost comes to about 10 centimes for electricity produced from nuclear, about 20 to 24 centimes for electricity from coal, and about 30 centimes for electricity from oil. [A centime equals 0.22 cents.]

You should also know that the price of electricity produced by the fast breeder is high, because it includes a large amortization of the construction. For about 20 years, it adds 28 or 30 centimes per kilowatt-hour. So, *a priori*, it makes sense to use nuclear energy, since it is one-third as expensive as electricity produced by oil and one-half as expensive as the electricity produced by coal. However, it requires an enormous investment. Creys-Malville, for example, will cost between 7 and 8 billion francs [$1.6-$1.8 billion]. This is entirely sustainable in France, but what developing-sector countries could afford this type of project?

Question: If developing-sector countries had access to large amounts of



CEA

"The countries that do not build fast breeders will not multiply their resources. Any nuclear program must naturally lead to a fast breeder program." Here, the French Phenix fast breeder.

credit at low interest rates, couldn't nuclear become viable for those that have the proper infrastructure?

Certainly, but you still have to calculate the cost. If you take a country like Brazil, is it more to its interest to develop hydroelectricity or to build a nuclear plant? If Brazil has uranium, it makes sense for its energy independence to build a nuclear power plant. But if it doesn't have any, then from the standpoint of the profitability of the kilowatt-hour produced, it is more to its interest to produce hydroelectric power. So the answer varies from one area to another.

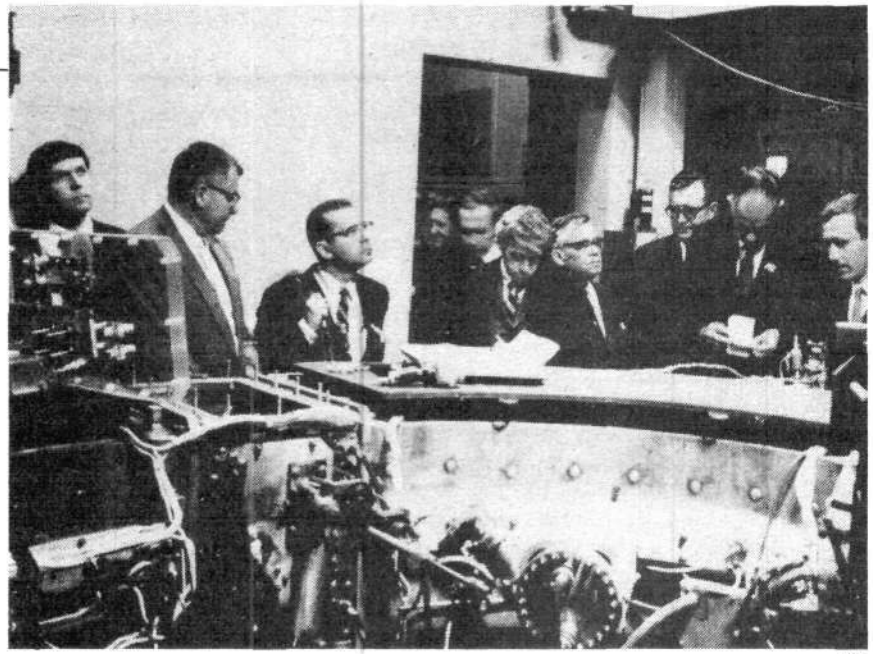
To take the example of Mexico, which has enormous oil resources, does it pay off more to build an electricity plant that runs on oil or to build nuclear plants in addition?

For us in France, the problem is a simple one. We have coal that is very mediocre and so not very usable, we have exhausted all our hydroelectric possibilities, we have built dams everywhere we could, and we have no oil. So we are absolutely obliged to launch ourselves into a nuclear program, even if this does not please everyone.

Question: Fifty or sixty years from now, when countries like Mexico begin to exhaust their oil resources, do you think it will become indispensable for the entire world to go nuclear?

Yes, unless we find something else. Forty years ago, no one dared to talk about nuclear energy, and there is still something about it that seems unthinkable at the present time. No one, however, now knows what contribution can be made by solar energy—not solar energy on the ground, of course, but in space stations. No one can say what will come of this. So the answer is yes, for the 20 or 25 years to come we must have nuclear.

Question: Now let us take up the problems involved in the creation of a new international monetary system, a system that will ensure credits for technology transfers. Do you think that France, for historic and other reasons, has a particularly important role to play in the creation of this new system?



DOE

"The industrially advanced countries form a community. . . . All scientific breakthroughs—such as a breakthrough in fusion—will necessarily become international breakthroughs very rapidly." Here a U.S. team led by Atomic Energy Commission chairman Glenn Seaborg visits the colliding beam accelerators at the Institute of Nuclear Physics in Novosibirsk.

We have come to the end of the monetary system as we know it today. We cannot continue indefinitely with the present system, which is characterized by the creation of artificial dollars by the international banking system in order to mobilize the resources produced by oil. Each year, new quantities of Eurodollars are created that are theoretically transformable into dollars, to a point today where the Eurodollars, petrodollars, Asiadollars, and so forth in circulation represent two and a half times the total fiduciary circulation in the United States.

Second, we are reaching a point where the weight of the dollar in the world has been considerably weakened, simply because trade is much more developed. During the 1950s, the dollar represented 50 percent of the reserves held by national banks throughout the world. Dollar reserves have now fallen to the level of 17 to 18 percent, because the number of developed national economies and the mass of circulating international goods have multiplied considerably.

Now the dollar continues to be managed on the basis of the national interests of the United States alone. This is becoming more difficult for the rest of the international community to accept. This, combined with the fact that the dollar is becoming a totally artificial currency (since it is composed of one element that is the fiduciary dollar circulated inside the United States and of another element created by international banks outside the United States), has led to the end of the monetary system as we know it today.

This is part of a set of factors that will make it necessary to build an international monetary system, if we want to avoid a crisis of the dollar as an international currency.

Question: France and West Germany took a step in this direction with the creation of the European Monetary System. But its second phase, the European Monetary Fund, has been postponed until 1982. What are the obstacles preventing the implementation of phase two?

The monetary problem is a techni-

cal problem and a problem of confidence. Each currency must conform to a certain necessity. In the European framework, we still find ourselves with currencies that fluctuate excessively. It is only after our currencies have stabilized little by little—this is what they are doing now, since the European currencies live together and are the expressions of economies that are more and more interconnected—that we can move to the next phase, the European Monetary Fund. This is inevitable, because to the extent that the economies are becoming more integrated, the currencies will necessarily follow, but they will follow at a distance. At the present time, there are still excessive monetary fluctuations, because there are international games that come to bear on these currencies.

Question: You are saying that implementing the second phase will depend on achieving stability first. Don't you see the possibility of creating the fund first in order to achieve that stability?

Yes, if there is an international monetary crisis in which the European countries decide to create the European Monetary Fund in order to protect themselves, to protect their economies. But if this international monetary crisis does not occur, we will have to wait for the stabilization to take place first, before there is a kind of monetary integration as advanced as the economic integration. What is slowing things down is the international capital flows that come to bear on each currency. There is money coming in from the Arab countries to Germany, to England, and even to France, creating artificial movements of capital. One day it will be in Europe's interest to protect itself collectively, in order to prevent these imbalances from occurring, which are not good for the currencies or the economies in question. England, for example, is certainly suffering economically from having a pound that is too strong and from experiencing large influxes of capital from the Arab countries.

Continued on page 54

Soviet Fusion Leader Interviewed

Velikhov Welcomes U.S. Fusion Bill

"Mastering thermonuclear fusion is one of those grandiose projects that is scarcely possible without broad international cooperation."

In a New Year's Day interview with the popular Soviet weekly Literary Gazette, *fusion physicist E.P. Velikhov welcomed international progress in fusion development, including passage of the Magnetic Fusion Energy Engineering Act of 1980, the "McCormack bill," in the United States. Velikhov, vice president of the Soviet Academy of Sciences, is a leader of the Soviet fusion effort.*

Noting that "the role of fusion in the energy industry of the future will constantly increase," Velikhov stressed the importance of international cooperation on fusion research. Excerpts from his interview follow:

Mastering thermonuclear fusion is one of those grandiose projects that is scarcely possible without broad international cooperation. There are in the world today approximately 50 tokamaks, which have cost billions in monetary expenditures, the development of very sophisticated technologies, and, of course, the intellectual energy of many talented researchers.

I might point out that the very selection of the tokamak as an excellent basis for fusion research is a good example of how fruitful such cooperation is. This successful principle, discovered and preliminarily developed in our country, served as a powerful push forward for thermonuclear fusion work all over the world. (And this is not superfluous to recall now, when people in the West are asserting that cooperation with "those sneaky Russians" is a one-way street.)

The triumphal march of tokamaks is continuing. There is an experimental reactor being built in the United States on this basis, which should be fully installed at Princeton University by the end of 1981. The West European countries have pooled their efforts for the creation of a joint tokamak in 1983-84. Last September, the United States adopted as law a national nuclear fusion program, exceeding in scope the program to put a man on the Moon, and this should conclude with the creation of a tokamak-based thermonuclear fusion power station by the end of the century.

Tokamaks: Simple and Reliable

The tokamak is evidently one of the simplest and most reliable thermonuclear confinement designs, which is fully projected forward from its current status to the stage of a functioning thermonuclear reactor. It has been discussed in detail not only by specialists in individual countries, but by the International Council on Fusion Research, which works in Vienna under the International Atomic Energy Agency (IAEA). . . .

In 1978, the Soviet Union submitted a proposal to the International Atomic Energy Agency: to unite the efforts of scientists of all countries for the creation of an international tokamak. This would make it possible to join together all the achievements of today's tokamak machines. This proposal was adopted, and draft work on the international thermonuclear fusion tokamak reactor, Intor, is proceeding. True, a place for building it has not yet been chosen, although the Soviet Union, Austria, and several other European countries have offered their territory.

I think that carrying out this international project, where "everyone is working for everyone," will be a fine example of the materialization of detente, a condition essential for the truly fruitful development of international science.

DOE

Israel's role in the development of nuplexes, agroindustrial complexes centered around one or more nuclear plants, was a central part of the Fusion Energy Foundation's Mideast Peace and Development Program issued two years ago. Above: the research reactor at Dimona.

Nuclear Option Brightens for Israel

Ever since Israel became a state in 1948, there have been voices raised in the country for Israel to "go nuclear." And Israel has had access to a nuclear capability for the last two decades at its reactor facility at Dimona. However, it is only in the last six months that nuclear energy has been discussed as a serious future energy option for Israel.

The new pronuclear mood among Israeli scientists and the general population is in part attributable to the defeat of the Carter administration, which had refused to sell Israel a reactor that had been promised during the Nixon years. According to the Jan. 23 *Jerusalem Post*, the prevailing assessment now in Israel is that "at the very least, President Reagan will honor his campaign pledge to end the freeze on building nuclear power stations in the U.S., and may even revert to the nuclear export policy of the Nixon administration."

The *Post* noted that a reinvigorated American nuclear program would have "important spin-off effects for Israel, if it decided to use outside help and experience to build its own reactors," a project that is now feasible technically but would take eight to ten years to complete without outside assistance. This process, the *Post* said, could lead to "a nuclear-based economy in Israel."

Pronuclear Organizing

The post-Carter optimism in Israel was expressed in the keynote speech of Israeli Nuclear Society head Shimon Yiftah to the society's annual meeting at Ben-Gurion University of the Negev last December. Also promoting the nuclear option at the December meeting was Professor Alvin Radkowsky of the Tel-Aviv University School of Engineering, who is active in organizing scientists across Israel. Dr. Radkowsky, who formerly worked with Admiral Hyman Rickover in the United States, has developed a new design concept for building light-water pressurized reactors.

A second impetus for nuclear energy is coming from a group of scientists associated with the Israeli Academy of Sciences Committee for Projecting the State's Needs in Basic Research. The committee issued a report in late 1980 calling for a strengthening of research in plasma physics, the scientific field necessary for the development of thermonuclear fusion power, in view of "its importance when applied to the world's energy problems." The committee also called for research into quantum electronics, lasers, astronomy, and astrophysics.

The future of the nuclear option in Israel now hinges on the work of a government-appointed commission, which is to present its findings this April. The head of the commission is retired General Amos Horev, presently head of the Haifa-based Technion Institute, a key training ground for Israeli scientists and engineers. In a speech in late November, General Horev warned that the current stagnation in the training of scientific and engineering personnel in Israel "will seriously limit the country's aspirations and capabilities in the future."

Prior to the completion of the Horev commission's work, several possible sites for building nuclear plants in Israel are being investigated. One of the more interesting possibilities involves the building of nuclear reactors underground. An interdisciplinary team from the Israeli Atomic Energy Commission has been established to study this possibility, and its findings will be released sometime in early to mid-1982.

If, as expected, Israel's government changes hands when elections are held in June, the prospects for nuclear power are likely to be even brighter. Shimon Peres, Labour Party candidate for prime minister, is a long-standing advocate of the nuclear option. In a speech to a Labour Party policy-making convention Feb. 1, Peres stated that under his rule Israel would be committed to "a vast range of development enterprises" and "several large national projects," including "establishing nuclear power plants."

—Mark Burdman

Global 2000:

Will the Zero-Growthers Capture the White House?

Most Americans considered the voting in of the Reagan administration last Nov. 4 a decisive blow against environmentalism in the United States. Yet, a group of zero-growthers in and around the Reagan administration—including prominently Secretary of State Alexander Haig—are planning to sell the environmentalist doctrines of the *Global 2000 Report* to the new administration.

The Global 2000 Report to the President, a project of former President Carter's Council on Environmental Quality (CEQ) and the Vance-Muskie State Department, was released in spring 1980 and immediately endorsed as policy by the State Department, the White House, and various members of Congress.

The report calls for a sharp reduction in world population growth between now and the end of the century, stating at the beginning: "If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. Serious stresses involving population, resources, and the environment are clearly visible ahead. Despite greater material output, the world's people will be poorer in many ways than they are today."

On Jan. 14, less than a week before the Carter administration left Washington, the CEQ and the State Department released the implementation document of the *Global 2000 Report*, titled *Global Future: Time to Act*. This document makes specific the zero-growth doctrine left general in the original report.

Among the new recommendations are: an almost exclusive emphasis on so-called renewable energy resources like solar power and the limiting of energy use by advanced sector and developing nations alike; strict control of "hazardous waste" in the United States and other advanced countries to the point of severely limiting future industrial development; the definition of water as a scarce resource, forcing the adoption of backward agricultural technologies that use less water; and a global "pollution watch" and concern for the environmental impact of all trade and development projects.

For the United States and other advanced countries, the new report means reduced living standards and an end to scientific progress. For the Third World, it means a ban on technology transfer—and thus enforced underdevelopment and genocide.

It is not surprising, therefore, to find that the technocrats who have been involved in the different phases of the *Global 2000* project cite the work of the Brandt Commission as parallel to their own. (The Brandt Commission, an offshoot of the World Bank, touts "appropriate technologies" for the Third World, with special emphasis on developing indigenous energy sources such as wind and solar power, organic fertilizer, and so forth.)

CEQ staffer Nicholas Yost and Thomas Pickering of the State Department oversaw the second, *Global Future* report, which involved more than 13 interagency taskforces and 1,000 outside consultants. Former Attorney General Benjamin Civiletti loaned a key aide, Christine Hall, for coordinating purposes. But the éminence grise behind the whole operation was Russell Train, head of the World Wildlife Fund-U.S. and the arch-environmentalist who formerly directed the Environmental Protection Agency. Train loaned a top aide, Mike Wright, to work on the final project.

How will it be possible to inject zero growth into the Reagan administration? "You do not understand how many friends we have in the new administration," Nicholas Yost told a journalist recently. "We have what you can call major channels of influence." At the top of the list he placed Secretary of State Alexander Haig, whom he described as a "closet environmentalist."

Former NATO commander "Haig fully understands the national security implications of the doctrine of limiting population growth and development to managing potential crises" and of the necessity of convincing the Soviet Union to adopt convergent, antitechnology policies, a source at the Natural Resources Defense Council said.

Underneath Haig, former New York Senator James Buckley, the newly appointed undersecretary of state for security affairs, is a very strong supporter of the Global 2000 doctrine. The leading supporters in the new Congress are Sen. Claiborne Pell (D-R.I.), a member of the U.S. association of the Club of Rome, and Rep. Richard Ottinger (D-N.Y.), who introduced legislation Jan. 19 calling for a national population policy aimed at achieving zero or negative growth "stability" in the United States.

This pernicious inside operation in

Continued on page 61

NSIPS

The Global 2000 faction intends to replace the American System with deindustrialization and zero growth.

National Academy of Sciences: Turning Away from Science?

This spring the National Academy of Sciences, America's most prestigious scientific organization, will present its Public Welfare Medal to an individual who has worked against industrial progress and science in this country for the past decade. Former Environmental Protection Agency administrator Russell E. Train will receive the award at the academy's 118th annual meeting April 28, in recognition of his "continued and far-reaching contributions to the quality of our environment and to public action for its protection."

Train, a tax accountant by profession, was head of the President's Council on Environmental Quality in the early 1970s and EPA director later in the decade. In these positions he was instrumental in pushing through legislation that broke with the American tradition of science-vectored industrial progress, banning many useful and safe pesticides; forcing American industry to invest in costly and inefficient "pollution abatement" equipment, to the detriment of investment in innovative technologies; and imposing a restrictive land use policy on resource-rich expanses of the country.

Train is currently president of the U.S. branch of the World Wildlife Fund, an institution whose international head is Prince Bernhardt of the Netherlands and whose mission has been to perpetuate a feudalist outlook. Train is also a founding member of the German Marshall Fund, the creator in 1979 of the Brandt Commission, which has promoted "appropriate" technology instead of the modern technology required for developing the Third World.

And, as noted in the accompanying article, Train was instrumental in framing the environmentalist *Global 2000 Report* and its follow-up implementation report, *Global Future: Time to Act*.

Fusion polled several prominent academy members and found them all outraged at the Train award. Many planned to protest to academy president Philip Handler.

Domestic Uranium Under Threat

It is a real possibility that the United States, with by far the most extensive uranium resources of any nation in the world, could soon find itself 50 percent dependent on foreign producers for its uranium supplies—the same Australian, Canadian, and South African producers who, as parties to the early-1970s international uranium cartel, drove up world uranium prices from $5 to $40 per pound and created havoc in the U.S. nuclear industry.

A number of well-placed uranium market analysts are predicting that this will be the case by the mid-1980s. And late last year, Senator Pete Domenici of New Mexico demanded a Department of Energy investigation into the long-term viability of the U.S. uranium industry and the effects of low-cost foreign imports.

Domenici's concern, according to his aides, is that the current depressed conditions in the uranium market could force irreversible shutdowns in the domestic industry, leading to severe unemployment and economic hardships in the western mining states and creating a U.S. dependence on foreign suppliers whose reliability is questionable. The results of the DOE study, which is being conducted by the department's Division of Resource Assessment Operations, should be released this spring.

The main source of the industry's problems is the precipitous drop in uranium prices over the last few years, primarily a result of the decline in nuclear electric generation and the phase-out of new nuclear orders during the four years of the antinuclear Carter administration.

Spot market prices for uranium dropped from more than $43 per pound of milled product in 1978-1979 to $27 per pound in Jan. 1981. This is at or below the cost of production for an estimated 50 percent of domestic uranium mines, according to DOE experts.

There have been other aggravating factors, too. During 1980, utility companies began actively selling off their burgeoning inventories, which now stand at around 120 million pounds, or six years' uranium supply at current consumption levels.

The SALT II talks, with what some analysts believed to be implications for an East-West freeze on all nuclear technology, also weighed down on prices.

The other ingredient has been the aggressive worldwide marketing campaign by new Australian mining consortia. The development of the continent's high-grade ore deposits was stalled in the mid-1970s by obstruction by the Friends of the Earth, Australian aboriginal tribes, and the country's Labour Party government, contributing to the rigged increase in prices in the early 1970s.

Together these factors have contributed to the unabating price decline and hard times for the U.S. uranium industry. Unemployment is running more than 20 percent among miners in Senator Domenici's home state of New Mexico, and there have been extensive mine and mill shutdowns throughout the western uranium states.

Small Miners Hit Hard

Whereas the Union Carbides and Anacondas are large diversified companies that can absorb the financial loss, the smaller miners cannot. And as in the petroleum industry, the small independent operator plays a critical role in the uranium mining process.

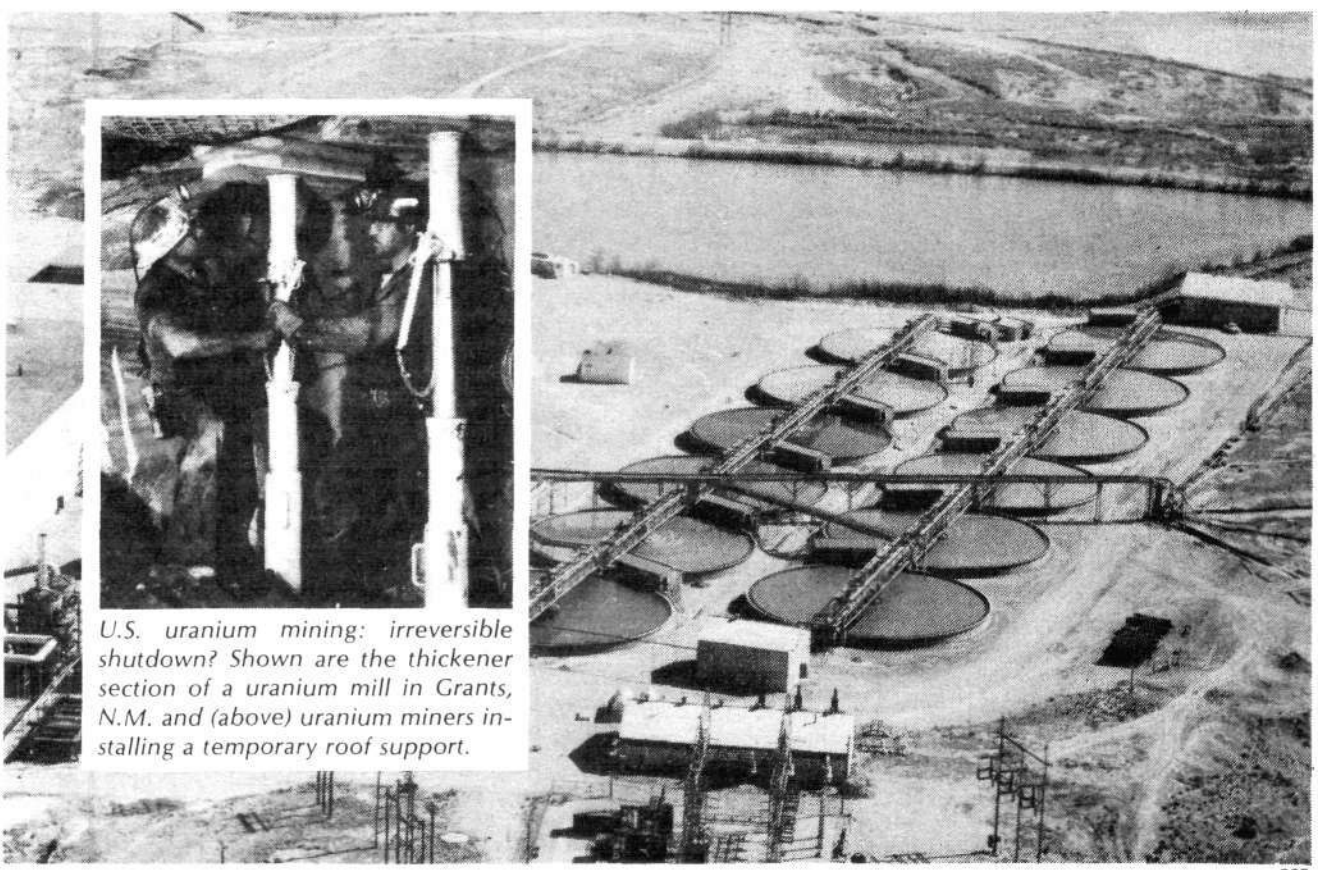
The Western Small Miners Association, which includes both small and large mining concerns in 11 western states, points out that large companies like Union Carbide and Anaconda have historically contracted properties out to small independent operators, who can often mine the deposits more efficiently. But with the current slump in uranium demand, Union Carbide has terminated all of its independent operator leases, and many miners have been forced into other areas such as synfuel development.

The high cost of meeting government regulations is another source of the growing financial crisis of the small miners, according to the Western Small Miners Association.

The threatened closing of United Nuclear Corporation's Church Rock, New Mexico mill is a case of the outright environmentalist blockage the uranium industry faces. UNC was granted a 60-day reprieve to counter the state Environmental Improvement Division's claim that seepage from the mill's tailings pond is contaminating underground aquifers. Otherwise, the mill will be shut down, and along with it will go more than 600 jobs and a mine with an estimated 35 million pounds of uranium, which could be mined for another 20 to 25 years.

(In its peak year 1978, the UNC operation produced some 2 million pounds of uranium oxide, or enough reactor fuel to operate five 1,000-megawatt reactors per year, or the equivalent of 50 million barrels of oil annually.)

At the Jan. 9 hearings the state



U.S. uranium mining: irreversible shutdown? Shown are the thickener section of a uranium mill in Grants, N.M. and (above) uranium miners installing a temporary roof support.

DOE

Environmental Improvement Division could present no positive evidence to back up its charges against UNC. However, the agency is demanding that the company prove that it is *not* contaminating the underground water—an unheard-of negative proof, by nature difficult, which could set a dangerous precedent for toxic waste cases across the country.

A New Uranium Cartel?

Some uranium market analysts think that the threat to domestic uranium production is nothing to worry about—foreign producers can provide the United States with lower-cost nuclear fuel. But what about the reliability of supply?

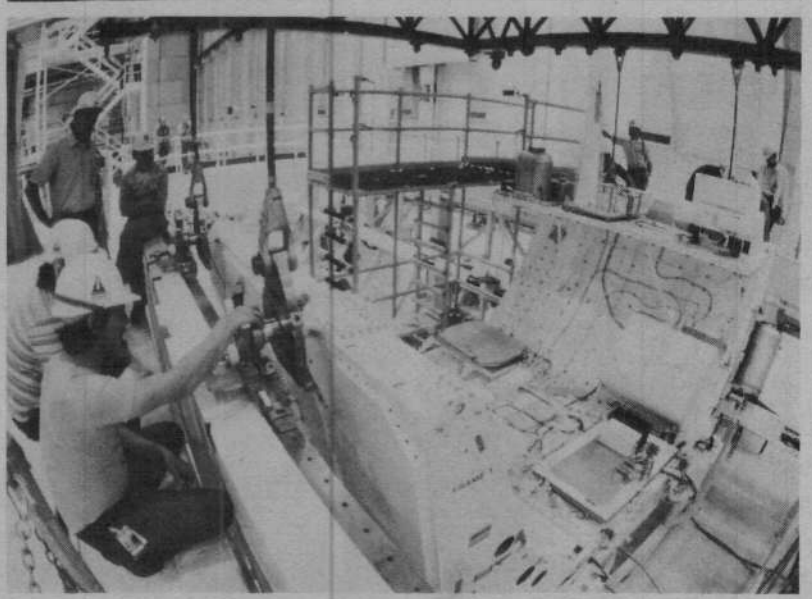
"Some utilities think that foreign uranium is like oil from Iran," commented Robert Pitman, one of the DOE officials involved in the Domenici study. "Of course, Canada, Australia, and South Africa won't be as unpredictable, though there have been some worrisome statements from the opposition Labour Party in Australia."

However, serving as a reminder of the disruption caused by the earlier uranium cartel is the recent spate of multi-million-dollar, out-of-court settlements in the antitrust suit Westinghouse brought against 29 uranium producers for engineering the price runup. The fivefold rise caught Westinghouse short of millions of pounds of uranium committed for delivery to customers at fixed prices, and it led to suits, countersuits, and, to date, five years of litigation.

Gulf Oil, the main defendant in the suit, claimed that the Canadian government had required it and other producers operating in the country to join the cartel. Getty Oil, a second defendant, submitted that its Australian operations were covered by that country's secrecy laws. (Getty is currently developing one of the new Australian deposits.) Rio Tinto Zinc of London and eight other foreign companies similarly cited national secrecy laws and contended that they had no liability under U.S. law.

Does the United States want to become dependent on these producers for its nuclear reactor fuel?

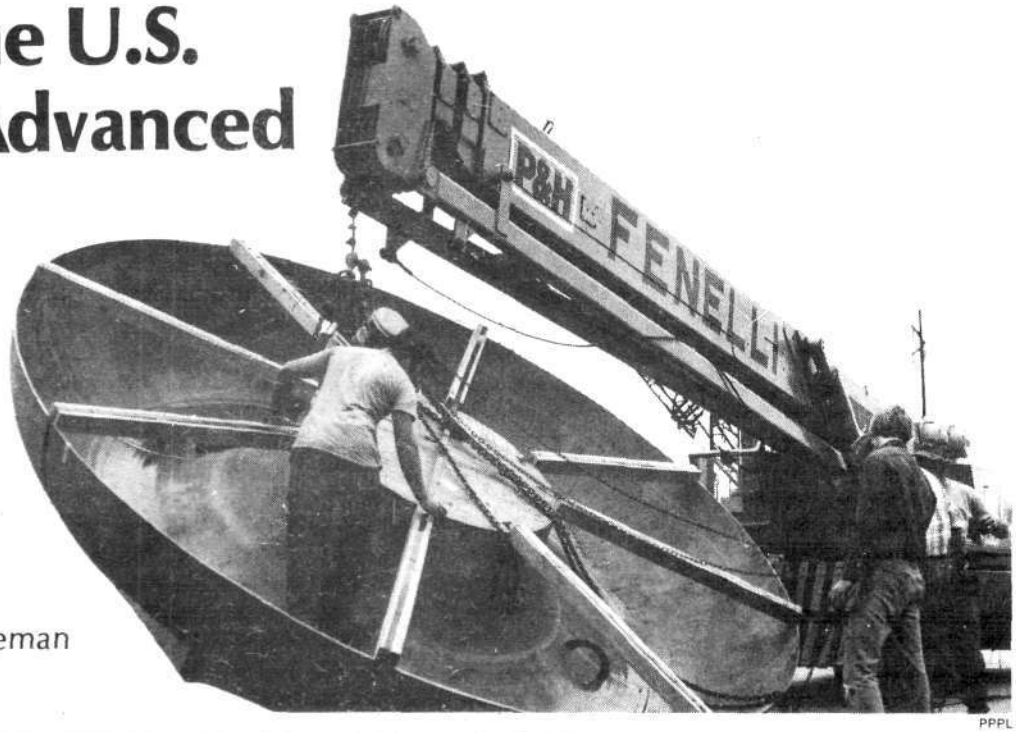
—Lydia Schulman



NASA

The space shuttle Orbiter Columbia is now scheduled for launch in April. The world's first reusable space vehicle, it will be the most complicated craft ever flown—launched like a rocket and landed like an airplane. When fully operational in the mid-1980s, the shuttle will open up space to scientific experimentation and specialized manufacturing performed not only by astronauts but by scientists and trained technicians. Shown above is the Orbiter Columbia traveling to its test site; below is the first payload to be carried into space.

Will the U.S. Back Advanced R&D?



PPPL

Above: work on the PDX tokamak vacuum vessel at Princeton.

by Marsha Freeman

Reagan Energy Policy Still Cloudy

The direction the Reagan administration will take in important energy areas, particularly those that involve advanced technology R&D and basic research, is still not clear at this writing. Although the president decontrolled the price of domestic oil as one of his first acts in office and has indicated there will be regulatory changes to allow already commercial technologies such as nuclear energy to return to a healthy growth, the fate of government-supported research and development efforts is still a matter of speculation.

One example of the policy standstill on the executive level is the fact that weeks after his appointment DOE Secretary James B. Edwards has not filled even one appointed position in the DOE. No science advisor to the president has been named, nor the director for the Environmental Protection Agency, nor the Council on Environmental Quality; and a position remains vacant on the Nuclear Regulatory Commission.

The policy perspective fight that has produced this paralysis has the Milton Friedmanites on the budget-cutting side, versus most of the scientific community and the economic pro-growthers on the other.

The OMB Battleground

The split has been out in the open in the policy recommendations coming from the new head of the Office of Management and Budget, David Stockman, and the reactions his recommendations have provoked. Here the Heritage Foundation and supporters (see article below) are pitted against New Mexico Senator Harrison Schmitt and other prominent scientific spokesmen.

In a memo to Reagan in December 1980, OMB designate David Stockman named the National Aeronautics and Space Administration (NASA) as a "low-priority" agency whose budget he wanted to cut by one-third. Later, in mid-January, Stockman said that long-term R&D programs would have to be stretched out or delayed.

Stockman's rationale for this suicidal recommendation, which seems to ignore the President's commitment to increase productivity in the U.S. economy, is that a large part of the $30 billion in proposed federal budget cuts will have to come out of R&D because it is a "controllable" part of the budget—as opposed to Social Security and other social programs that are mandated by law.

Other recent proposals along these lines are that a 10 percent cut in the NASA budget could be achieved simply by cutting out the Galileo project, a mission to Jupiter.

The Heritage arguments for cutting government-supported research and development are along the lines that such work should be left up to the devices of private industry—a "free

enterprise" view that ignores the role of new technologies in a growing economy.

The strongest voice against this kind of free enterprise "meat axe" approach to the budget has been Senator Schmitt. Schmitt, along with his former colleague in the Senate, Adlai Stevenson, an Illinois Democrat, had taken great pains over the past four years to explain to senators that investment of federal tax dollars in R&D is *deinflationary*, at the same time that the Carter administration was hacking away at NASA, the fusion program, and advanced nuclear R&D.

"I've seen statements attributed to Congressman Jack Kemp and Congressman Stockman and George Shultz to the effect that the economy needs a shock treatment, and the treatment should be administered without discrimination, wherever there is money to be cut," Schmitt told *Science* magazine Dec. 19.

"I frankly think that is unnecessary and extraordinarily dangerous. You might have a brief pulse of improvement, but the country will start going downhill again very rapidly unless we rejuvenate our technological base."

The Government's Role

As for the government's role in energy policy, Schmitt said: "In the short term we have no alternative but to produce more oil and natural gas. . . . We can use coal in an environmentally safe way and nuclear power. . . . In the long term there are so many alternatives, it is difficult to decide which ones to pursue most vigorously. I believe that within 10 years . . . we could demonstrate the commercial feasibility of fusion power, and within 20 years we could have a major commercial fusion plant in operation. . . . As portable fuel we will eventually be headed toward hydrogen."

Does that mean the government's commitment in synthetic fuels is misguided, Schmitt was asked. "Yes," he replied. "It means that the synthetic fuels industry will be controlled by political forces and not economics."

When the policy fight had not neared resolution by mid-January, Schmitt escalated his offensive going directly after Milton Friedman, the economic guru of the austerity faction. Friedman's advice on R&D policy "must *not* be taken as the last word on the need for government support of certain types of scientific research," Schmitt wrote in a letter to the editor of *Science* Jan. 19.

"Friedman's solution [to the imbalance in private and federal research funds] would be catastrophic to the future of the country, its economy, and freedom itself. To advocate the abolishment of the National Science Foundation, the National Institutes of Health, and federal support of higher education is like treating brain tumors with a guillotine.

". . . Government must fund those costly research and development programs, such as in nuclear fusion, space, defense, and global environment which are obviously necessary but far beyond the risk-taking potential of the private sector. . . ."

The fact that the OMB's Stockman has persisted in his threat to make extreme cuts in these very areas is the clearest indication that Senator Schmitt and his allies have not yet won the fight.

Wide World

Stockman: the meat-axe approach

'Agenda for Progress'? **The Heritage View**

The most specific recommendations for revising the fiscal year 1982 federal budget in line with the Friedmanite austerity policy perspective have come from the Heritage Foundation, which in early January published a report titled *Agenda for Progress, Examining Federal Spending*.

In what Heritage describes as a "market approach" to the federal budget, the foundation actually proposes to destroy the government's positive policymaking role. Specifically, Heritage advocates eliminating government support for the science, research, and development of new technologies—the backbone for continued growth of the civilian economy.

Although the Heritage Foundation has tried to position itself as the "conservative think tank" for the new administration, it is striking that all public policy statements from Senate Republican leaders and progrowth executive spokesmen have lambasted the Heritage recommendations.

The major fallacy in the Heritage report is stated in the chapter on general science, space, and technology: "A salient feature of federal research is that it is 'controllable'; it can be adjusted from year to year with no drastic near-term effects on the nation as a whole."

Apparently the authors do not plan to be around for long enough to miss the technological benefits desperately needed in the economy.

Specific Recommendations

In terms of specific recommendations, Heritage lists a "reexamination of the economics and the institutional arrangements for space transportation," which would include such alternatives as the discontinuation of the Space Shuttle program. Heritage doubts that the shuttle will prove to be an "economical" system, when all the present federal R&D development costs are taken into account.

If the U.S. government decides it does want to continue the program, Heritage says, then "a longer-term approach would be for the federal government to turn the space transportation services over to the private sector and to purchase space transportation services as necessary for research and national defense activities." Of course, this would require a complete rewriting of the legislation that established NASA as primarily a national resource for space science, national defense, and research. Not even OMB head Stockman has suggested, as Heritage has, that NASA should be sold off to industry.

On the energy front, the Heritage Foundation laments the fact that federal intervention into the Tennessee Valley Authority has led to a premature demise of the otherwise prosperous windmill industry by introducing nuclear power into this showcase of American energy technology. Heritage's solution? Sell the TVA, the Bonneville Power and Authority, and other national resources to "private enterprise."

Heritage also calls for the decontrol of all domestic energy production, regardless of the impact on the economy, and development of future advanced technology. According to Heritage, the "free market" can decide what research is in the national interest.

What this means concretely can be seen in the fact that the Heritage report chapter on energy never mentions the word "fusion." Perhaps fusion is implied under the Heritage category of "other technology." However, how can something called an *Agenda for Progress* ignore the only R&D program that promises to eliminate the world's energy supply problems?

"Other technology," by the way, is slated by Heritage for a cut to $608 million in fiscal year 1982, compared to the current estimate of a 1982 budget at $872 million. Heritage never names the programs it would include under this category.

As for nuclear energy, the Heritage report agrees that the government should be involved in nuclear energy development, not to promote economic growth but because of "the very real national security issues surrounding nuclear technology."

The breeder, Heritage says, is probably "not an effective investment" and instead a "cost-benefit analysis would probably show that R&D money would be better spent to develop the technology of light water resources." What the free market will do when the United States runs out of economically minable uranium is not discussed.

DOE

Edwards: "I reject the concept of conservation that focuses on no-growth policies."

DOE Secretary James Edwards:
A Basically Sound Approach

The man appointed to run the beleaguered Department of Energy, James B. Edwards, set forward a positive and basically sound energy approach at his Senate confirmation hearings Jan. 12:

"In my own lifetime I have seen things come to pass not even imagined in the days of my childhood. Americans are problem solvers. We should not try to regulate genius. We should turn it loose on the next frontier, whether it be in the vastness of space, the core of the atom, the surface of the Moon, or the complexity of meeting the energy needs of a growing, thriving, and prosperous nation," Edwards said.

The hearings were a dialogue between Edwards and the Republican senators leading the Energy Committee who attempted to lay the ground rules for a sound energy production and development policy. For many in the hearing room, including this reporter, the Edwards testimony stood out as the antithesis of the philosophy of former DOE secretary James Schlesinger, with his harangues about the "moral equivalent of war" and "sacrifice."

In his opening statement to the committee, Edwards said straightforwardly: "I reject the concept of conservation that focuses on no-growth policies. . . . The human body uses the least energy when it is asleep—or, in the extreme, dead. I want Americans to choose their lifestyles—not have it dictated to them. I want to see America awake, strong, and alive. I want to see America employed, producing and consuming—growing. I reject any idea of energy conservation that stems from fear of the future. I am better off than my forefathers, and I expect Americans' children to have a better life than we do. I want to give them the tools to do it with, including concepts that are only gleams in the eye inside a research laboratory today. I want to build for the future, not bunker down in the foxhole of the present."

Edwards continued: "Tomorrow's energy menu is whatever our ingenuity can make it. Fusion, the nuclear breeder, wide scale use of renewables—each has both promise and challenges. . . ."

In a radical departure from the previous administration's reason for establishing the DOE, Edwards concluded by saying: "The mission of the Department of Energy is to serve the

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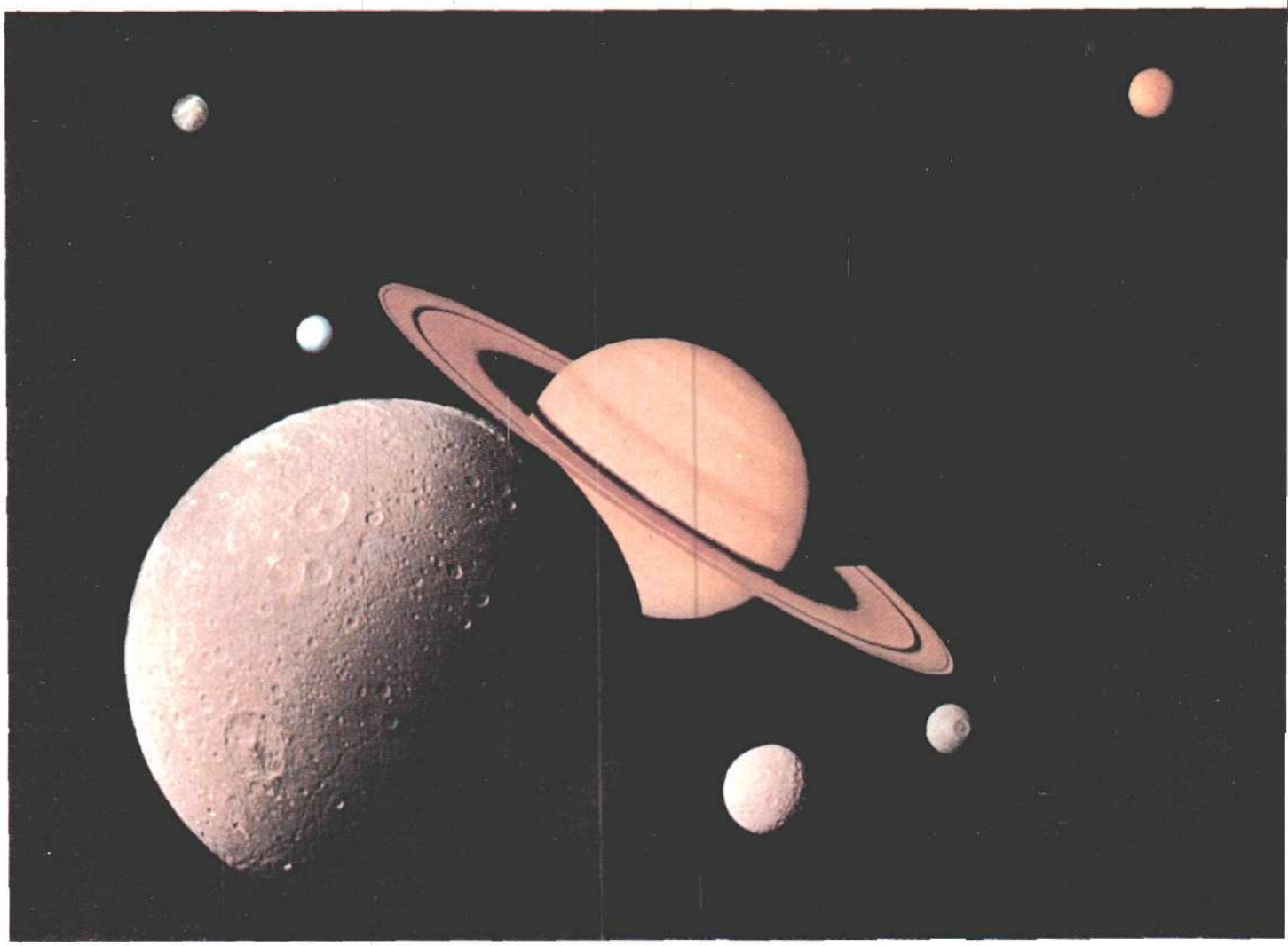
The Saturn Puzzle & the Origins Of the Solar System

by Dr. John Schoonover



The thermohydrodynamics of the early Saturnian system may provide the explanation for the novel structures of the planet observed by Voyager 1.

Newton had good reason to emphasize mathematical laws as opposed to physical explanation because the central physical concept in his celestial mechanics was the force of gravitation and the action of this force could not be explained at all in physical terms. The concept of a gravitational force that attracted any two masses to each other even when separated by hundreds of millions of miles of empty space seemed as incredible as many of the qualities that the Aristotelians and medieval scholars had invented to account for scientific phenomena. The concept was especially repugnant to Newton's contemporaries. . . . The abandonment of physical mechanism in favor of mathematical description shocked even the greatest scientists. Huygens regarded the idea of gravitation as "absurd" because its action through empty space precluded any mechanism. . . . Many others including Leibniz objected to the purely mathematical account of gravitation. Leibniz began his critique in 1690 after reading Newton's Principia and he kept it up until he died.

—Morris Kline, in *Mathematics: The Loss of Certainty*

The November 1980 encounter with Saturn by the Voyager 1 spacecraft has provided a wealth of data on many aspects of the planet's structure that will keep scientists busy for years to come. Some of the newly discovered features can be easily explained in terms of existing ideas and accepted theories. Others, and these are the most interesting, present a challenge to the basic concepts that have informed celestial mechanics for several centuries.

In many respects, Saturn can be thought of as a microcosm of the solar system. It has a large number of satellites, just as the Sun has numerous planets circling it. The ring system, as we shall see below, can be treated as a laboratory for stellar formation processes that might have occurred, had the early Sun been slightly different.

The important questions to ask about a complex system like Saturn are how did its particular features become what they are now? To deal with this kind of question, it is essential to understand the evolutionary processes that brought the present complex system into existence from a relatively homogeneous earlier state. Specifically, how could such a complex, highly organized, and—according to usual considerations—improbable structure come to exist? More precisely, what kind of universe would support such a structure as a stable form of matter? It is the ontological significance of Saturn that represents its interest for scientific inquiry.

The problem scientists face here is like the problem biologists face in trying to explain the workings of a cell. Many biologists would approach the cell from its composite parts, attempting to build up the complex mechanism from an accretion of random events, governed by fixed chemical laws that describe how things can combine. Following this approach to its final logic, the existence of a living organism becomes an event of such minute probability as to appear fortuitous. The hapless biologist is left with two choices: Either there is no rationality in the universe and living things have come to be despite the virtual impossibility that they could, or some agency external to the workings of the universe has intervened to create living things. Both hypotheses amount to the same thing.

The alternative to this impasse is for the biologist to recognize that self-organizing processes are the primary substance of the universe. The particular emphemeral forms that this organization takes are the nodal points, the singularities mediating subsequent stages of self-organization on a higher developmental level. Furthermore, a lawfully determined transformation of laws governs subsequent evolution.

For biology, the case is sufficiently clear that at least some biologists adhere to an approximation of this perspective on evolution. Unfortunately, however, nearly all physicists would deny the reality of any hypothesis that remotely resembles this one, although they too are attempting to explain the workings of the very same universe the biologists are looking at.

Why is this the case?

The essential content of Newtonian physics is deeply imbedded in the thought and practice of most physicists, despite the fact that in recent years, researchers in me-

chanics have conclusively proven that Newtonian mechanics, in the broadest meaning of that term, is incapable of providing answers to this type of question. The three-body problem and its solution is a case in point, as Dr. Steven Bardwell has shown.[1] Just as Ptolemy was able to mirror the actions of the planets with some accuracy, by including sufficient numbers of epicycles, so Newton and his followers have been able to quite accurately describe some celestial motions. But at the same time, vast areas of relevant phenomena are inexplicable by Newton's approach and, worse, are ruled *a priori* out of bounds.

The Three-Body Problem

For example, as soon as a third body is introduced to the Newtonian system, all lawful ordering of processes goes out the window. If three bodies interact as point masses according to Newton's laws, then no matter how similar the states of each group of three particles are before collision, they can have arbitrarily large differences in position or velocity after a near-collision. To quote from Bardwell's study of the three-body problem: "The rigorous consequence of a reductionist physical law is the unlawfulness of the universe! . . . Since we are not in danger of being hit by flying third bodies, we must conclude that pairwise interaction of singular particles cannot in principle be the basis of a correct physical description of the world."

As Bardwell shows, these indeterminacies—associated with the "infinities" in the point-interaction description—must be replaced by the concept of physical singularities acting within a hydrodynamical phase space of complex geometry.

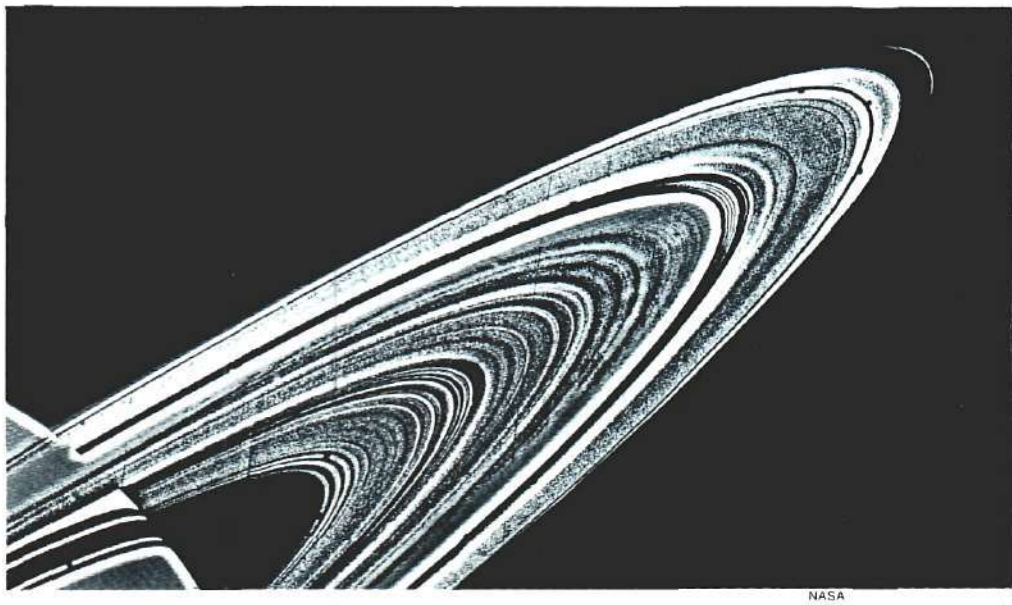
The Saturnian Laboratory

The Saturnian system provides a good example of the kind of phenomena that Newtonian mechanics can describe, but not explain. Two of Saturn's moons, S10 and S11, which were recently discovered, engage in a complex mutual interaction brought on by the fact that they share almost identical orbits. One of the moons appears to gain on the other in such a way that it looks as if the moons would ultimately collide. But as they approach, the leading moon pulls away, avoiding the collision.

This motion is a classic case, known as a horseshoe orbit, of a special form of three-body interaction that can be described in approximation. The three interacting bodies are the two moons and Saturn. If the problem were solved in its full form, the motion of the three bodies would become indeterminate. In its full form, the problem calls for mutual gravitational attraction between Saturn and each of the moons and attraction of the moons to each other. In addition, all three bodies are free to move under these forces. To arrive at an actual solution, though, it is necessary to use the fact that Saturn is so much larger than either of the moons that it remains essentially fixed in space, while the moons revolve about it.

In this way, the unsolvable three-body problem is reduced to a manageable two-body problem with the two bodies moving in a central force field from Saturn in addition to their mutual attraction. The trailing moon, say S11, is in a lower orbit than S10. This means that it will complete one revolution about Saturn faster than S10 at its higher orbit. Kepler showed this to be the case for planetary motion early in the 17th century. Now, as S11 begins to gain on S10, their mutual attraction becomes stronger. The effect of this is to accelerate S11 and retard S10. This acceleration and retardation of the two satellites has the effect of a torque, increasing S11's angular momentum, while decreasing S10's. Consequently, S11 must move into a higher orbit and S10 into a lower one.

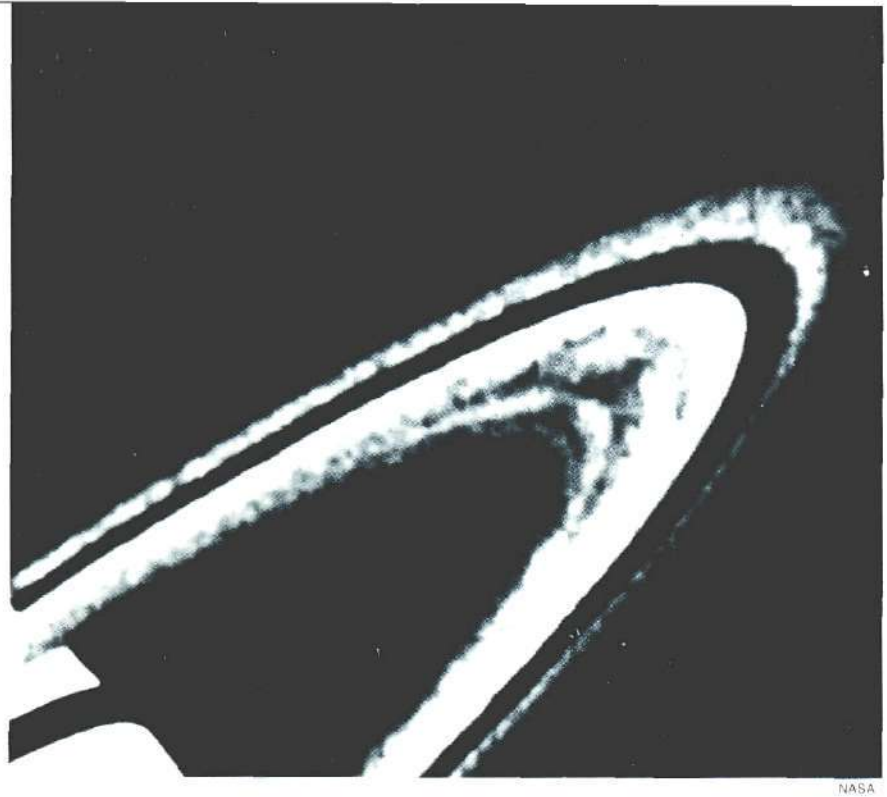
Now, S10 will complete a revolution more rapidly than



NASA

Voyager team members were astounded with the first pictures showing the highly differentiated structures within the ring system. Some of the major features like the Cassini Division, the dark band about three-quarters of the way out from Saturn, had been explained years ago in terms of resonant interaction with the moon Mimas. According to the theory, there should be no material in the division. However, there are a number of clearly visible rings within it. The F ring is faintly visible in upper right corner outside the apparent outer boundary of the A ring.

The existence of such highly differentiated structure within the rings is pointed evidence that we do not understand celestial mechanics. This structure exists even down to the smallest scale on which today's instruments are capable of resolving images of the rings. Standard gravitational theory would predict smooth, monotonic behavior, not the dynamical singularities that are evident here. The question remains open as to what kind of field could generate this kind of structure as a stable feature of the ring system.



NASA

One of the surprising features of the Saturn ring system is the appearance of the so-called spokes. Visible here as radial dark areas within the otherwise light ring, the spokes maintain their integrity over periods of several hours. To do this they could not be governed simply by motion that is the result of the rotation of ring material about Saturn. In that case, the inner material would revolve in a much shorter time than the outer, breaking up the structures. The spokes seem to be moving with the same period of revolution as the planet's rotation, giving rise to the hypothesis that they are an artifact of interaction of Saturn's magnetic field with charged microparticles in the rings.

S11, so it appears to pull away from the imminent collision. Eventually it will catch up with S11, and the motion proceeds in the same way, returning the two moons to their former relative positions. Seen from one of the moons, the other appears to execute a horseshoe-shaped motion.

This description of the motion is all very well, but it does not tell us anything new. It is a precise, mathematical way of saying that the moons are doing what they are doing. For one thing, this approach cannot explain how two satellites could come to occupy the same range of orbits, a highly unlikely event. This, in fact, is a question that some of the scientists studying Saturn are asking themselves.

A Hydrodynamic Model

Recently there have been some promising attempts to answer this kind of question. A group of theoretical physicists headed by James B. Pollack of Ames Research Center has been working on a hydrodynamic model of both Jupiter and Saturn's evolution throughout the lifetime of the solar system—about 4.5 billion years.[2]

One of the first things to notice about both planets is that they are composed largely of hydrogen and helium, the same elements that are dominant in the Sun and other stars. Furthermore, both planets have been found to radiate more energy from their surfaces than they receive from the Sun. This observation led Pollack's group to seek an internal energy source in the planets to account for this excess energy radiation.

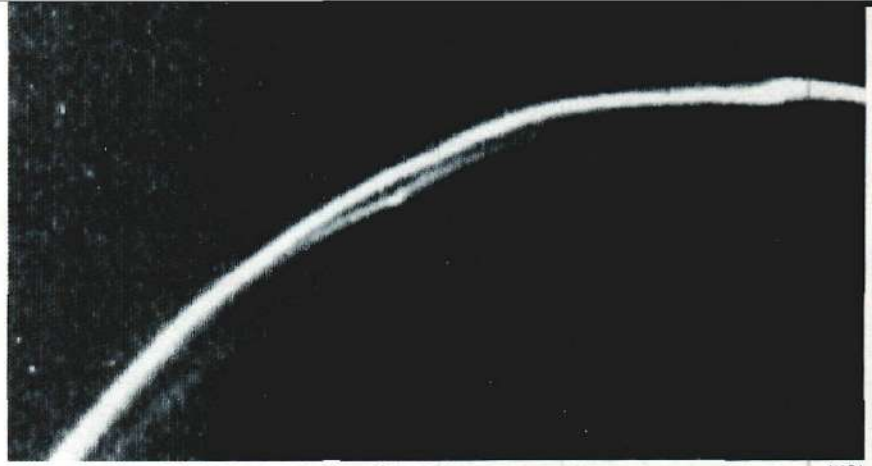
The idea they struck upon was to treat the planets as if they had evolved from gas clouds in the same way that a small star might have evolved. This is not to say that Saturn and Jupiter are stars undergoing thermonuclear fusion in their centers. They are too small to achieve the pressure and temperature conditions for that. Nevertheless, treating Saturn and Jupiter in this fashion has led to some tentative explanations for many of the gross features of both planets discovered by the Pioneer 11 and Voyager missions.

Stars form when very large gas clouds, perhaps hundreds or thousands of times larger than the solar system, develop internal instabilities and begin to contract. One hypothesis for the origin of such instabilities is that a supernova explosion of a nearby star generates a shock wave in the gas cloud. There seems to be some evidence that this is the way the Sun was formed. However, there must be other ways for the initial instabilities to arise, since there must have been stars before there were supernovas.

As the gas cloud that became the Sun was undergoing contraction, other instabilities were created, one of which led to the formation of Jupiter, another, Saturn. The reason for these instabilities is not yet known, and is an important question that must be dealt with to develop the causal connection within the solar system's history.

However, taking the beginning of this contraction as given, the complex evolutionary process that leads to the current state of Saturn can be discerned. At the center of the contracting gas cloud, more and more heat builds up as the contraction progresses. Eventually, the temperature becomes high enough for hydrogen molecules to dissociate into atomic hydrogen and even to ionize. Extensive zones of hydrogen in these two phases develop within the region near the center of the gas cloud. This condition induces hydrodynamic instability and the cloud undergoes a very rapid collapse that ends only when it is several times the current size of the planet. This collapse, which starts when the cloud is some hundreds of times the current diameter of the planet, lasts only about one year.

After this period, contraction proceeds much more slowly, and the heat built up in the interior during the prior phase is slowly dissipated. One of the early successes



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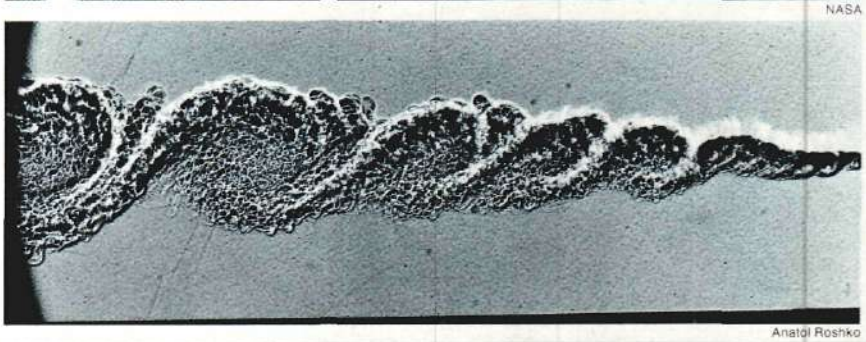


Anatol Roshko

The F ring, shown on the top, appears to be constructed from at least two or three braided rings. Explaining this structure provides a significant challenge to accepted ideas in celestial mechanics. Below is a telling photograph from experiments performed by Anatol Roshko, G. L. Brown, and M. Rebollo at the California Institute of Technology. The experiments were to observe the patterns of vortices produced when two different gases streamed past each other at different speeds. In this figure, which corresponds to a relatively high difference in the gas speeds, the vortices appear to be taking on a three-dimensional twisted shape. Perhaps something of this hydrodynamic nature is occurring in the F ring.

of Pollack's group was to account for the observed excess heat from Jupiter using this model. The group has subsequently found that the Saturn situation is not as well described. The problem is that the model predicts only about one-third as much heat being radiated today as is observed for Saturn.

The discrepancy may be because the equations of state (the equations that describe the detailed behavior of a material) for hydrogen and helium are not very well known in the density and pressure ranges encountered in Saturn's interior. Both above and below the range encountered inside Saturn, 0.1 to 1.0 g/cm^3 and about 3 Mbars (1 megabar is a unit of pressure equal to 10^5 newtons per square meter), the equations of state are much better known from terrestrial experiments. Much of the information has been developed in conjunction with work on hydrogen bomb design and inertial fusion research.

One other possible source for the discrepancy is that below about 10,000 degrees Kelvin and at pressures around 3 Mbars, hydrogen is in the metallic phase. Under these conditions, helium may become immiscible in the hydrogen and sink below it toward the center of the planet. This process would generate additional heat beyond that already projected. It would take about 30 percent of the helium going through this process to make up the additional heat necessary to account for Saturn's present rate of heat radiation.

Although the gas cloud is still fairly extensive, objects floating through it may become trapped because of frictional drag. They would then start to spiral into the center, building up a core of solid material in addition to the gaseous mixture of mostly hydrogen and helium. This process can continue right up to the point when the cloud rapidly contracts. If an object is trapped only a short while before the contraction sets in, the cloud will collapse beneath it, leaving it in orbit around the planet.

This seems to be the mechanism to explain how the "irregular moons" of both Jupiter and Saturn came to be in their present orbits. Their irregularity is a result of the fact that their orbits are much more elliptical than those of the regular moons. Furthermore, some revolve in the opposite direction to the rotation of the planet.

Formation of Regular Moons

At the end of the collapse phase, a disk of material, gas and dust, rotating with the planet is left behind. This serves as the source material for the regular moons that form in this region. During this early period in the planet's life, the excess heat being radiated would be many times what it is now, so that it would dominate the temperature conditions in the disk where the moons were forming. By carrying out detailed calculations of the temperature across the disk, Pollack's group has determined that it would have been too hot for water vapor to condense in the region where the two inner Jovian moons, Io and Europa, were formed. In the case of the next two, Callisto and Ganymede, water vapor could condense. These results are indirectly confirmed by measurements of the densities of these two moons. It turns out that Callisto and Ganymede are less dense than Io and Europa, a fact that could be accounted for by the presence of ice in the makeup of the former, but not of the latter.

Since Saturn is less massive than Jupiter, its excess heat production would have been a factor of 10 lower. This means that objects could collect ice at closer distances. Then, the inner moons of Saturn should have ice as a significant part of their composition. From the Voyager measurements of the size of these moons, their densities have been found to agree with this projection.

Another expectation from the model is that ammonia and methane would be able to condense in the region of the outer moons of Saturn, since the temperature there

NASA

Saturn (left), just like Jupiter (center), has a highly organized atmosphere with long-lived vortical structures and bands flowing at different speeds. The planets should provide insights into the complex evolutionary characters of hydrodynamic systems. Saturn's largest moon, Titan (right), has a dense, layered atmosphere of nitrogen, with significant amounts of hydrocarbons. Scientists hope to learn something about the early chemical evolution of Earth's atmosphere from Titan.

would have been lower than it was closer to Saturn, where water vapor could condense. This seems to account for the composition of Titan's atmosphere. It has been confirmed that Titan, Saturn's largest moon, has an atmosphere composed largely of nitrogen, with some methane and ammonia in it. The preponderance of nitrogen can be explained if the atmosphere was originally largely ammonia. Since ammonia readily decomposes into hydrogen and nitrogen in sunlight, the hydrogen could escape the moon's atmosphere, leaving the nitrogen behind. If Jupiter's four inner moons, which are about the same size as Titan, had formed farther from the planet where ammonia and methane could have condensed, they too would have developed atmospheres.

Similarly, with less excess heat production, Jupiter could have formed a ring system like Saturn's. Within a certain distance from a planet, it becomes impossible for a large body to withstand the tidal forces, similar to those that produce tides on Earth's oceans. The closest approach to a planet that a large moon could make without being destroyed by tidal forces is called the Roche limit. Furthermore, material distributed inside the Roche limit cannot form into a large body. The disk surrounding Saturn was cool enough at an early date that water vapor could condense into ice. So, the rings did form around Saturn, composed largely of ice, while it was too hot for condensation to occur near Jupiter.

Challenge to Celestial Mechanics

From this account, it is clear that some of the features associated with the birth and evolution of the two largest planets in the solar system can be at least partially explained using the model of the behavior to be expected from a small star's formation. There are many questions yet to investigate, perhaps by successfully refining this model. The most visually spectacular question to be answered is why are Saturn's rings so intricately differentiated? How can a rotating hydrodynamic system produce the observed separations of different-sized particles that give the rings the appearance of a phonograph record? Another important question, and one with implications for the process of planet formation, is how do the regular moons form in the planetary disk?

The standard Newtonian approach to this problem has been to assume that if chunks of matter bounce around long enough, some of them will begin to stick together, gradually building up to planetary size. To say the least, this mechanism is highly fortuitous. No doubt, enough monkeys playing with typewriters long enough could produce Shakespeare's works. But just as Shakespeare did not produce *Hamlet* fortuitously, the universal self-evolutionary processes that produced Shakespeare were themselves more organized than the random bumping around this model of planetary accretion implies.

The place to begin looking for a viable mechanism is in the production of hydrodynamic singularities in the star-forming medium that became the Sun. The kinds of gravitational instabilities that initiated the formation of the Sun, and, according to Pollack's model Jupiter and Saturn, appear to have universal significance for generating the conditions under which diffuse gas bodies can become entities capable of highly organized evolutionary differentiation.

For example, can the Sun be treated in a full plasma and hydrodynamic model, including rotational effects? Under these circumstances, is it possible to follow the course of differentiation of materials so that the dense rocky planets are formed closer to the Sun, while the giant, largely gaseous ones like Jupiter and Saturn form farther out? Important questions to determine include whether shock waves could form resulting from the dynamical features of the early Sun's evolution, and whether they could provide mechanisms for generating gravitational instabilities that could cause the planets to form.

Or, perhaps in a complex system such as the presolar gas cloud, it is possible to generate another type of hydrodynamic singularity, such as a train of vortices that propagates outward from the center of the cloud, creating regions in which planets could condense.

Such a theory should account for, among other things,

the empirical relation known as the Titius-Bode Law. This law states that the distances of the planets from the Sun in multiples of the Earth's distance form a simple series approximately given by the relation

$$a = 0.4 + 0.3 \times 2^n.$$

The significance of this relationship is compounded by the fact that it also holds for the regular satellites of both Jupiter and Saturn. Although the relationship is not exact, it does hint that there is an order, determined by a lawful process, to the spacing of the planets themselves, and the satellites of these two large planets. The existence of the Titius-Bode Law is an indication that the process leading to the formation of the large planets could be significantly similar to that for the Sun.

Recent discoveries in turbulence theory by G. L. Brown and A. Roshko indicate that large-scale structure is superimposed on the apparent randomness usually associated with the development of turbulence in fluid media.[3] In the accompanying photograph, the vortical pattern seems to have achieved a three-dimensional braided structure as it has evolved through a number of reorganizations of the vortices, and the F ring of Saturn seems to be doing something very similar. To account for the more and more large-scale reorganization observed in turbulence studies means to abandon the notion that order is dissipated into disorder, and to replace it with the idea that apparent randomness is merely the appearance of disorder on a scale where the subsuming order is not perceived. But the complex organization of the solar system and its Saturnian subsystem provide eloquent testimony to the primary *ordering principle in the universe.*

For too long, many scientists have attempted to understand the universe by building up the omnipresent stable, complex structures from more elementary particulars. It is time that that compulsive irrationality stops. The primary substance of the universe is its stably evolving highly ordered states becoming more highly ordered. Scientists must start from this perspective and work down to locate the significance of the particulars embedded in order. Saturn is a spectacular laboratory in which to study this quality, for it offers the critical experiment to show that two-body interaction is not the foundation of dynamics, and that the self-ordering, dynamical, geometrical quality is primary.

Dr. John Schoonover, physics and astronomy editor of Fusion, *is working on a more detailed article on the many-body problem in astronomy showing the relative contributions of the Newton-Maxwell and the Riemannian schools.*

Notes

1. Steven Bardwell, "Solving the Three-Body Problem," *Fusion*, June 1978, p. 21.
2. James B. Pollack, Allen S. Grossman, Ronald Moore, and Harold C. Graboske, Jr., "The Formation of Saturn's Satellites and Rings, As Influenced by Saturn's Contraction History," *Icarus* 29 (1976), p. 35; "A Calculation of Saturn's Gravitational Contraction History," *Icarus* 30 (1977), p. 111.
3. The Brown and Roshko work is described in detail in "The Beginnings of a Deterministic Theory of Turbulence," Dr. Steven Bardwell, *International Journal of Fusion Energy*, Vol. 2, No. 4 (1981).

The Three-Body Problem

"The final goal of Celestial Mechanics is to resolve the great problem of determining if Newton's law alone explains all astronomical phenomena. . . . The Three-Body Problem is of such importance in astronomy, and is at the same time so difficult, that all efforts of geometers have long been directed towards it."

Henri Poincaré, in this description of the three-body problem, highlights one of the most difficult unsolved problems of mathematical physics, which is also the simplest nontrivial application of Newton's law of gravitational attraction: how do three point masses interact gravitationally?

The problem of the interaction of two bodies under the influence of a pairwise attractive force like gravity has long been considered to be solved. But as soon as more than two particles affect each other's motion, an important theoretical assumption is made: these three particles can only interact by means of the forces between each pair of them—there are no higher-order interactions possible within Newton's law.

Attempts to solve the three-body problem in this form have reached a surprising conclusion: if particles interacted this way in reality, the universe would not be causal. The work of R. McGehee and J. Waldvogel proves that (1) the three-body problem cannot be solved deterministically; and (2) no complete description of possible orbits for three bodies after a near collision has been found because there are a large number of trajectories in which one of the particles leaves the near collision with arbitrarily large velocity. Thus, if the underlying assumptions of Newtonian mechanics were true, particles could assume arbitrarily large velocities; their orbits could be infinitely sensitive to small perturbations; and their motion would contain a kernel of inherent unpredictability. Since the universe *is* causal, these mathematical results show quite conclusively that something is wrong with Newton, not the universe.

The Saturn data provide important evidence concerning the actual processes dominant in celestial mechanics. From this evidence and the internal contradictions in Newtonian mechanics, it seems that not only has the three-body problem not been solved, the two-body problem has not been solved! (Or, if it is considered solved, it was the wrong problem!)

The evidence from Voyager 1 proves very directly that the universe does *not* work as a collection of self-evident particles interacting as pairs—the fundamental assumption for all of Newtonian mechanics. Rather, the fundamental nature of the universe is self-ordering phenomena subsuming the motions of individual particles.

Far from being a competent educator or child psychologist, Jean Piaget was part of a project to contain the development of science.

Piaget's Role in Wrecking U.S.

by Mary Gilbertson

IN SEPTEMBER 1980, the world-famed child psychologist Jean Piaget died in Switzerland at age 84. Newspapers quickly filled up with obituaries, features, and tributes to Piaget and his influence. And indeed, his influence was extensive.

Do you wonder why Johnnie can't read, why Johnnie hates math, why Johnnie and his friends are so susceptible to the appeal of rock and drugs? The answer, in large part, is Jean Piaget.

Piaget shaped much of what currently passes as school curricula in America. His works are at the core of almost all teacher-training courses. Piaget's own classroom methods are widely applied, while his theories are the basis for many other methods that differ only in emphasis and shape educational practice at all levels. He was responsible for such innovations as "the open classroom," "the discovery method," "affective education," "individualized learning," "personalized education," and so forth—all of which stifle real intellectual development in children.

Perhaps the most notorious product of Piaget's work is often not associated with his name: "New Math." In 1958, the National Science Foundation began spending millions of dollars developing New Math curricula, effecting a broad revision in the subject matter by 1972. At present, the National Science Foundation, through Curriculum Development Associates, is developing a "New New Math" curriculum, again stressing Piaget's learning theory.

At the root of that theory is Piaget's assertion that mental powers of cognition are of no higher order than the "artificial intelligence" imputed to the action of a sophisticated computer. The child, according to Piaget, is like a computer, a "knowing system" that starts with certain initial properties—a "program"—and is fed information that it orders according to the structure of its program. The child's initial program or "structures" for receipt of information, as well as his later development, are ultimately *biological*. The child acts on the world, receiving sensory information, and the result is an "idea," which is the "structure" filled with sensory information called "experience."

The ideas achievable and the information that can be assimilated by the underlying biological structures, according to Piaget, are strictly delimited by the "stage" of biological growth. Only at a certain age, for example, do the structures become truly logical categories.

Piaget calls this model of learning "action-oriented structuralism"; his theory he dubs "genetic epistemology." "I decided to consecrate my life to the biological explanation of knowledge," Piaget states in his autobiography.

This explanation takes shape in *The Origins of Intelligence in Children* (1930), where Piaget writes:

> Verbal or cognitive intelligence is based on practical, sensorimotor intelligence, which in turn depends on acquired and recombined habits and associations . . . the relationship of thought to things.

In *Genetic Epistemology*, written in the 1940s, he repeats the same theory that learning and thinking are just human versions of training circus animals:

> Our hypothesis is that the roots of logical thought . . . are to be found more generally in the coordination of actions, which are the basis of reflective abstraction.

Incredibly, this totally sensory approach to learning that permeates all of Piaget's pedagogy became known as the *cognitive* school, despite the fact that his entire pedagogical perspective has nothing to do with the development of mind.

The reader may believe that children have "souls," or, more specifically, a cognitive power that cannot be reduced to a mere biofeedback system. Piaget says they do not: The human mind does not possess any creative qualities that could arrive at a conceptual solution to a problem that is beyond the ken of logical, deductive procedures and experience.

In the classroom that follows the Piaget pedagogy, children are to be treated as "soulless." Young children, according to Piaget, can learn only what they can see, touch, feel, and manipulate. Learning, like a rock concert, is a process of immediate, sensual gratification.

This is translated into "stages" in the school curriculum, conforming to the "stages" biologically delimiting a child's learning ability.

From birth through age 11, Piaget's stages restrict the child to "sensorimotor" activity and "concrete operations"; the teacher may introduce only those ideas that "classify" or categorize the objects and play in which the child is engaged. After age 12, the "formal operations stage" begins, a stage that lasts to senility. The adolescent and adult classify and categorize objects in the world for themselves, on the basis of logical manipulation that is merely the internalized expression of the "sensorimotor" manipulation of childhood stages.

Education

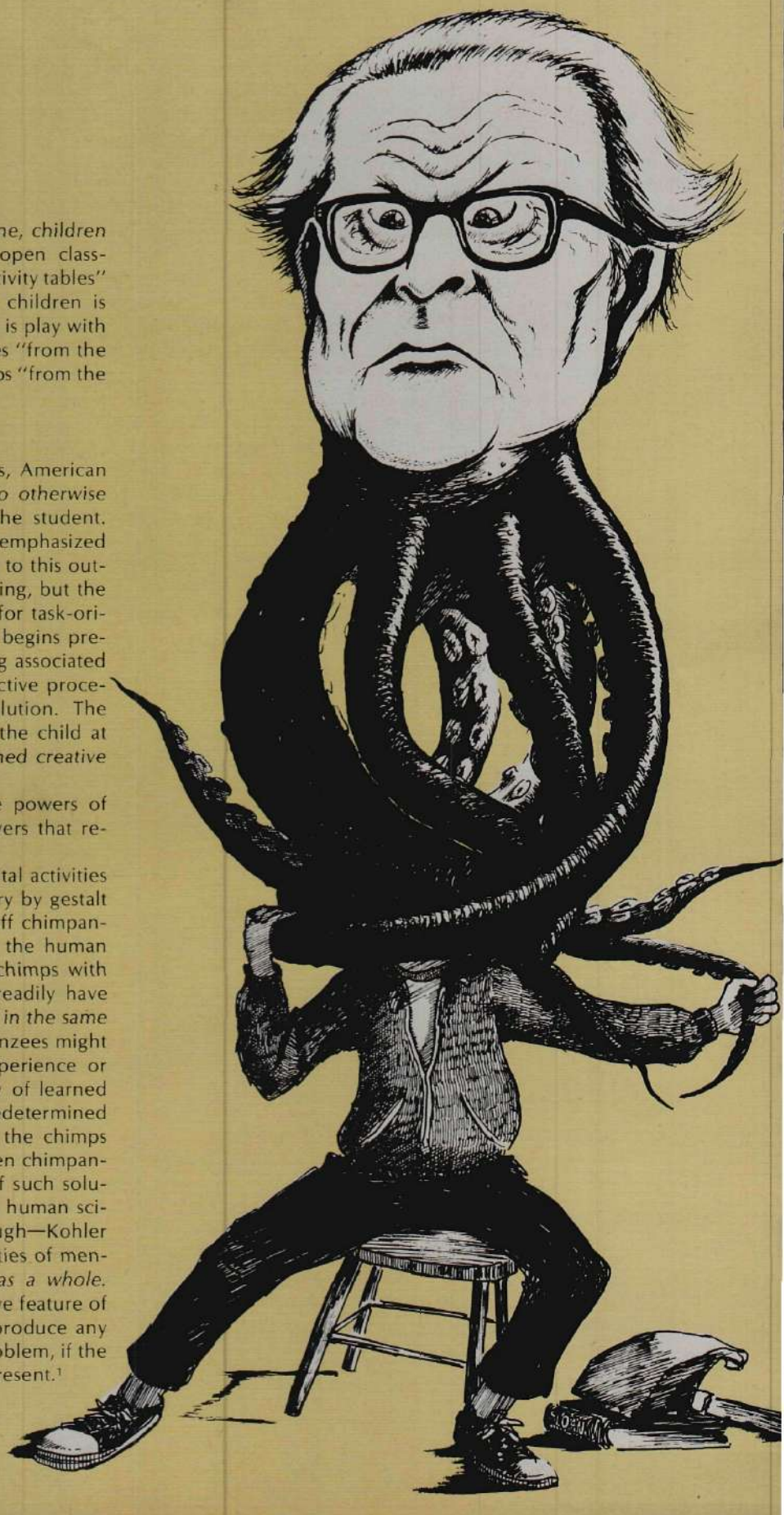
In schools run according to Piaget's doctrine, children and adolescents wander to and fro—"the open classroom"—going from "dress-up corners" to "activity tables" engaged in "fantasy play." Play with other children is considered irrelevant ("social"). What matters is play with objects, which is "biological": Learning comes "from the subject's own activity." All knowledge develops "from the body."

Cognitive Development

Prior to the impact of Piaget's innovations, American *education tended to represent a mix of two otherwise* irreconcilable approaches to the mind of the student. One, broadly termed classical or Neoplatonic, emphasized the child's *cognitive development.* According to this outlook, the goal of education is not mere learning, but the enhancement of the child's creative powers for task-oriented problem-solving in general. Education begins precisely at those junctures in which the learning associated with past experience and mere logical, deductive procedures fails to produce any satisfactory solution. The "breakthrough" to a solution demanded of the child at *such a juncture requires what is loosely termed creative* insight.

At issue is not only the solution, but the powers of cognition—the development of creative powers that repeated breakthroughs push forward.

The primacy of powers of "insight" in mental activities was proven experimentally during this century by gestalt psychologist Wolfgang Kohler and his Teneriff chimpanzees. Focusing on the discrepancy between the human mind and ape mind, Kohler presented his chimps with problems that he or a human child could readily have *solved, but that chimpanzees could not solve in the same* way. By eliminating problems that his chimpanzees might have learned to solve through previous experience or imitation—thereby eliminating the possibility of learned or deductive logical procedures—Kohler predetermined that the solutions to problems achieved by the chimps were creatively synthesized (*gestalt).* Since even chimpanzees could repeatedly develop discoveries of such solutions—representing the chimp analogue of a human scientific discovery or a student's breakthrough—Kohler conclusively proved that those creative qualities of mentation *are fundamental for mental activity as a whole.* Thus, it is proven that "insight" is a deliberative feature of mental processes that can be prompted to produce any valid solution that exists for a well-defined problem, if the potential ingredients of such a solution are present.[1]



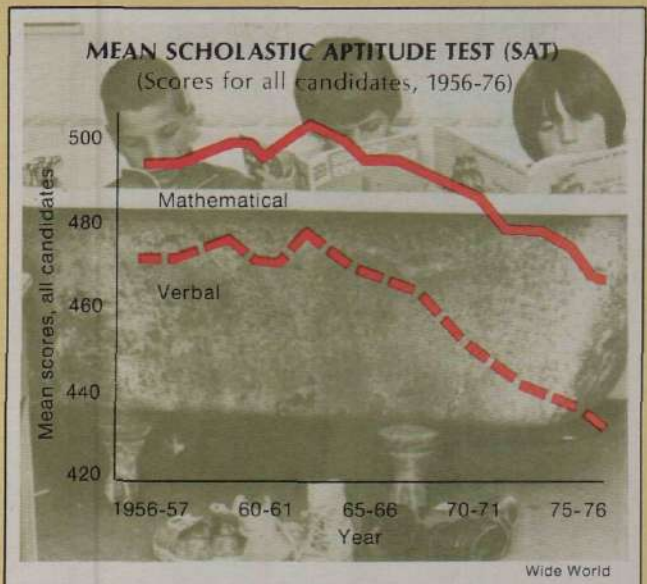
Therefore, the proper focus of education in general is the enhancement of this fundamental feature of mental life: *cognitive or conceptual development.*

One of the most important examples of how this actually functions in children is their demonstrated ability to rapidly master ever more complex musical forms as well as new languages. It is precisely within this notion of new knowledge involved in gestalt processes that Piaget chooses to make his attack. To Piaget, all knowledge tends toward what he calls "equilibration," states of equilibrium that are the opposite of gestalt processes.

In the United States, the classical influence in education has had to contend with a second, prevalent approach that emphasizes the child's imbibing and regurgitating answers. In this approach, which can be termed Aristotelian, education is mere learning and the recall of experience, on the basis of the logical deductive manipulation of data or the titles attached to objects and objectlike images.

From 1939 on, Piaget repeatedly attacked the gestalt psychology that had destroyed his "genetic epistemology" in a series of unassailable experiments. In the same period, he attacked the healthy side of U.S. education: "The *American disease is the rush to cognition,*" Piaget wrote.

The spread of Piaget's influence meant the banishment of cognitive development from the American curriculum. Instead, Piaget's methods defined school children as little bundles of biological impulses. Today, this is lawfully associated with the spread among American youth of the amoral outlook and psychological damage represented in an entire generation's susceptibility to the organized degradation of the rock-drug counterculture.



Wide World

It is no coincidence that U.S. verbal and math SAT scores declined at a rate proportional to the growing pervasiveness of Piaget's "child-centered," "fantasy-oriented" methods of pedagogy. Teachers polled in a 1977 Report of the Advisory Panel on the Scholastic Aptitude Test Score Decline, *sponsored by the College Board, listed both the New Math and the open classroom as reasons for declining scores. Background photograph is an open classroom scene in Concord, N.H.*

In one of his essays, Piaget himself writes of "the Dionysian excitement that ends in intellectual activity." This is a description of a writer of 20th century pornographic literature, the exact opposite of the fundamental emotions that generate knowledge and learning.

The Source of Piaget's Success

In the mid-1930s, British writer and intelligence chief H.G. Wells initiated a special project called the World Encyclopedia or World Brain. Jean Piaget's theories of learning and education were an official element in Wells's World Brain project, with the purpose of revising American education.

Because of powerful opposition to the project, ranging from Henry Ford (who denounced it as subversive) to President Franklin Roosevelt, Wells's efforts to conduct it through existing institutional channels failed.

During his 1937 trip to the United States on behalf of the World Brain project, Wells reported back:

> . . . *I have been giving a lecture in a number of* great cities about various possible educational expansions. I have been trying to interest people in schemes for knowledge organization and I have been talking to teachers, professors and educationalists in considerable profusion.

But, as Wells also reported, Americans at the top were suspicious or unresponsive. For example, he wrote:

> I did not think him [President Roosevelt] oblivious to the reality that America has to reconstruct its social life and cannot do so without a modernization of education from top to bottom, but I got a very clear impression that he did not feel in the least responsible.

The project leaders eventually resorted to the creation of a special government institution. Among others, the noted physicist Leo Szilard, a close associate of Wells in *the World Brain project, lent his public support to the* effort. The outcome was the creation of a Piaget faction within the new National Science Foundation.

Aside from some positive functions in funding basic research, the National Science Foundation became the World Brain's vehicle by which Piaget and related methods were inserted into the American educational system.

At the time he joined World Brain, Piaget was already a prominent figure in the network of ideological institutions and circles that Bertrand Lord Russell, a leader of England's Aristotle Society, had worked to foster internationally. Born in Switzerland in 1896, Piaget was trained in *zoology, obtaining a doctorate in 1918 with a thesis on* mollusks. In 1921 he became director of the Institut J.J. Rousseau in Geneva, and "obtained permission to work with the abnormal children of Salpetre," his first experience with pedagogy. (It is noteworthy that Rousseau's theory and practice of education were the most extreme

forms of mind-deadening "free school" methods ever devised.)

Piaget was subsequently given credentials as a psychologist, and in 1939, he was made a professor of sociology at the University of Geneva.

In 1940, Piaget became director of the Swiss Society of Psychology and he used this prestigious position to launch his attacks on Kohler's gestalt psychology.

Equally relevant to his World Brain involvement was his appointment by Julian Huxley as director of the International Bureau of Education within UNESCO during the late 1940s. Huxley's UNESCO and Wells's World Brain both sought to totally control the scientific content of popular education, for reasons that have been extensively documented.[2]

Piaget, Russell, and "New Math"

Jean Piaget's assignment within World Brain included not only work on the general method outlined in his stages theory, but also the development of a mathematics curriculum corresponding to the project's goals. Piaget consciously based this New Math wholly on Bertrand Russell's calculated misinterpretation of the work of the great Neoplatonic mathematician, Georg Cantor.[3] Especially useful to Piaget was the attack on Cantor's transfinite conception of number and set theory contained in Russell and Whitehead's 1902 book, *Principia Mathematica*.

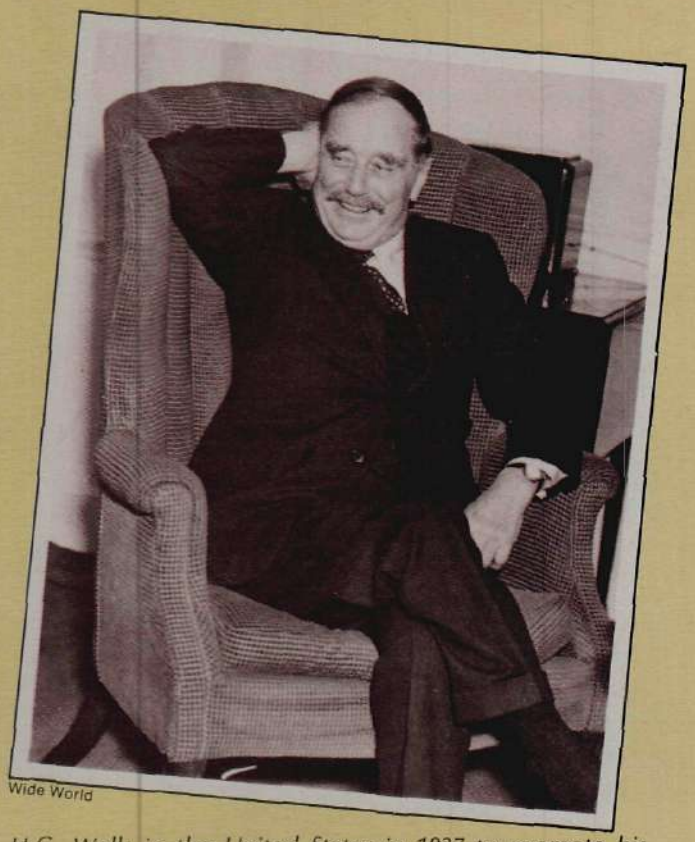
In one revealing passage, Piaget used Russell to attack both the creative insight Cantor consciously brought to bear on the foundations of mathematics, and the breakthrough in the concept of number Cantor achieved. Piaget states:

> The Platonist doctrines which Cantor persisted in mixing with his mathematical theories did not please everyone. . . . From a psychological point of view it would be especially interesting to have more precise knowledge about the intuitive vision claimed by Cantor. . . . It is very plausible that the development of set theory should have been stimulated by appropriate images, but it is difficult to believe in a more or less adequate intuitive vision of the totality of entities whose existence this theory requires; and if Cantor thought he had such a vision, he was probably the victim of an illusion.
>
> —*Mathematical Epistemology and Psychology*, 1966

Here is the crux of Piaget's fraud; for Cantor, in fact, described precisely the motivating concept behind his work, as is documented in the accompanying article on the New Math.

Instead, Piaget proposes to the credulous that Cantor's method of proof, which involves demonstrating that a one-to-one correspondence between the integers and more general types of numbers does *not* exist, shows that such a correspondence *does* exist!

> I have referred to the operation used by Cantor in the construction of transfinite numbers, namely, the operation of one-to-one correspondence. . . . This brings to mind immediately Russell and Whitehead's work in *Principia Mathematica*, where they define a number as the class of equivalent classes—equivalent in the sense of numerical equivalence established through one-to-one correspondence. . . . This view of the basis of the idea of number does seem to be justified . . . since in fact the number seems to be derived from one-to-one correspondence. . . . Russell and Whitehead's famous examples of equivalent classes makes a correspondence between the months of the year, Napoleon's marshals, the 12 apostles, and the signs of the zodiac.



H.G. Wells in the United States in 1937 to promote his World Brain project to revise American education.

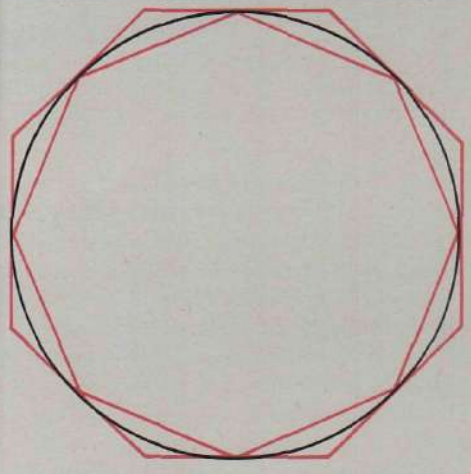
This has absolutely nothing to do with Cantor's conception that the number system is hierarchically ordered, reflecting the evolving, cognitive development of mathematical concepts. The higher orders of number have been generated from infinities in lower orders, in respect to which the higher orders are *transfinite*. Cantor thus identified the concept of number with a "generative principle" of development in the structure of mathematics.

One example can be seen in the requirement for making curved lines or surfaces subject to mathematical description. The geometric process is to proceed from the ordinary equilateral polygons to the infinitely sided polygon that asymptotically converges on becoming a circle. At that point, the number system that was adequate to describe the polygons reaches a *singularity*, the transfinite π (pi). Pi is a qualitatively new number. It arises from cognitive operations on a lower-order number set. But it cannot be formally reduced to the lower order of number.

Pi is also the basis for a whole new class of mathematical functions, the circular, or trigonometric functions.

In the same way, Cantor rigorously demonstrated that the structure and laws of mathematics mirror the universe and the human mind itself. Russell, on the other hand, sought to generalize the Aristotelian misinterpretation of mathematical discoveries into a form more appropriate to the description of Cantor's accomplishment. Piaget, in turn, sought to adapt Russell's perversion of Cantor for specific application to educational curricula along with adaptations of other structuralists of the Bourbaki school. The result was the New Math.

As the accompanying essay explains in detail, the essence of New Math is the formal reduction of qualitatively higher-order mathematical operations like division to simple lower-order addition and subtraction. In the process, the distinction between the new kind of number produced by division, a fraction, and the simple whole numbers of addition and subtraction is destroyed. In the classroom, however, addition and subtraction can be the subject of physical manipulations—but not the concept of rational number. So Piaget's "New Math" simply banishes that concept.



YOU CAN'T SQUARE THE CIRCLE

Various polygons can be inscribed inside or circumscribed around a circle in order to give an approximation of the circle's area and, therefore, the value of pi. These areas are related to the area of the simplest polygon, which is the triangle. It has been proven mathematically that the value for the area of the circle will always deviate slightly from the area of any of these figures, no matter how many sides the figure has. This is because although the area has a definite value, it cannot be expressed in terms of the rational numbers. The number pi, which expresses the relationship between the radius and the circle's area and the radius and the circumference is a qualitatively distinct number from the simple integers and rationals. This is a simple example of how both number and geometry involve an ordering of conception rather than any one set of axioms or logics.

In general Piaget laid out four principles when he began to develop the New Math:

(1) Eliminate the use of mathematical training for the child's cognitive development in general;

(2) Teach math as pure formal logic;

(3) Base the child's appreciation of mathematical concepts wholly on physical sensations; and

(4) Closely monitor the psychological effects of curriculum.

His principles proposed to substitute a "psychomathematical," totally sensuous process for the teaching of mathematics. In Piaget's method, children count physical objects of different types and find that the property of number is independent of the kind of object. Or, in his most famous example, Piaget proposes to have the child arrange pebbles in a circle, walk around the circle, and count the pebbles.

> The child went around the circle the other way and got 10 again. And no matter how he put the pebbles, when he counted them, they came to 10. . . . Commutativity . . . the sum is independent of the order. The knowledge that this future mathematician discovered that day was not drawn, then, from the physical properties of the pebbles, but from the actions he carried out on them. . . . In this sense, the abstraction is a reflection from the level of action to the intellectual level of operation.

In a similar "concrete operation," the child arranges and rearranges a set of pebbles, counting them each time. The rearrangements, like the order, do not make any difference to the number: the property of number is invariant under the transformations of order and displacement.

The "psychomathematical process" accompanying these trivial operations was described by Dr. Wilson of the University of Georgia, an expert in the development of New Math curricula:

> The New Math puts emphasis on structure—with associative, commutative, and manipulative operations. It turned to animation and gadgetry. Problem-solving did not get attached to New Math.

He might have added that mathematics or the relationship between geometry and physics did not get attached to New Math either.

Saving Education

Only one month after the death of Jean Piaget, a fusion energy development bill was enacted into law that commits this nation to achieving fusion power within the next two decades. That will require a mobilization of industrial and educational resources that makes even the high points of the NASA space program's effort pale by comparison.

America must produce tens of thousands of gifted scientists and mathematicians. These scientists and mathematicians must be trained in the conceptual approach to science taken by the school of Riemann and Cantor, a method already demonstrated in fusion laboratories to be uniquely appropriate to the analysis of the complex, self-

Piaget Vs. Chomsky: A Phony Debate

Much has been made of the "debate" between Noam Chomsky and Jean Piaget at the Abbaye de Royaumont near Paris in October 1975. All official accounts of the debate hold that the essential disagreement between them is over whether language is "innate" (Chomsky) or "constructed" through "inborn processes" in the young child and "the actual characteristics of physical objects and events" (Piaget).

Although some at the debate, like Jacques Mehler, a psycholinguist and colleague of both Piaget and Chomsky, tried to say that there were points of *convergence* between the two views, no one has noted that Piaget and Chomsky are of the same epistemological school. They are; in fact, Chomsky has done to language what Piaget has done to math.

Piaget went so far as to insist that the development of language is "structural" and has little to do with the mind but develops from body activity, which he called "semiotic functions." These, he said, are "all of a piece with acquisitions made at the level of sensorimotor intelligence."

Chomsky also divorces language from mind. The inventor of "artificial intelligence" schemes, "transformational grammar," and "structural linguistics," Chomsky treats language exactly as Piaget treats mathematics—a complex set of mere mechanisms or axioms that are "manipulated." Chomsky's emphasis in language is the structuralist notion of grammar where language is seen as "blocks of structure within which *words* are relatively incidental." This method of looking at language requires teacher-trainees to think that the significance of the English language is that you fit words into patterns like

the uggle wags a diggle.

This is used by the Chomsky school to prove that "arrangements of blocks of prose structure characterize English."

In sum, the content of thought is removed just as much from Chomsky's structural linguistics as it is from Piaget's structuralist math where an "example of equivalent classes makes a correspondence between the months of the year, Napoleon's marshals, the 12 apostles, and the signs of the Zodiac."

Piaget and Chomsky are indeed of the same epistemological school. Their historic debate centered on an issue (Is language innate?) that obfuscates the fact that they both agree in principle that cognitive development is not important.

ordering behavior of fusion plasmas. The nation, therefore, requires both a vast expansion and a qualitative upgrading in the cognitive content of its scientific education at all levels. Fortunately, there are many useful precedents to refer to and the Fusion Energy Foundation has already conducted a number of successful pedagogical experiments.[4]

From this standpoint, it is clear that Jean Piaget's innovations in American education now stand as a major obstacle to a program that could determine whether this and other nations survive through the coming century.[5] It is an urgent task to dump Piaget's discredited methods and put our nation's best minds to work recreating curricula at all levels of mathematics and science that permit our children to properly grow into the full creative use of their minds.

Mary Gilbertson, a Fusion Energy Foundation staff member, was a high school teacher for 10 years. Part one of her article, "The National Science Foundation: Taking the Science Out of Education," appeared in Fusion Feb. 1980, p. 53. Reprints are available at $1.25 postpaid.

Notes

1. For a discussion of gestalt theory, see Lyndon H. LaRouche's "What Is a Humanist Academy," in *The Campaigner*, Sept.-Oct. 1978, especially the section on ambiguity in poetry and music. Piaget never mentions the notion of ambiguity in terms of intellectual development. His inability to do so may clarify why he could never grasp Cantor's notion of increasing orders of internal differentiation that stems from Cantor's notion of power sets.
2. The full story of H.G. Wells, Bertrand Russell, Huxley, and their plans to contain scientific development is developed in detail in *The New Dark Ages Conspiracy* by Carol White (New York: The New Benjamin Franklin House, 1980).
3. For specific discussions of Neoplatonic approaches to mathematics see especially the remarkable 8th chapter in Book II of St. Augustine's *On Free Choice of the Will*, titled "The Order of Numbers, Known as One and Unchangeable, Is Not Known by the Bodily Senses." The Neoplatonic notion of math is directly stated, as can be seen from the excerpt of Augustine's dialogue with Evodius:

   "A. If someone were to say to you that numbers were impressed upon our spirit not as a result of their own nature, but as a result of those objects which we experience with the bodily senses, what answer would you make? Or do you agree with this?

   "E. No, I do not. Even if I did perceive numbers with the bodily senses, I would not be able to perceive with the bodily senses the meaning of division and addition. It is with the light of the mind that I would prove wrong the man who makes an error in addition or subtraction. . . .

   "A. I do not disagree with your answer, for you spoke truly and clearly. But you will easily see that numbers themselves are not drawn from the bodily senses, if you realize how any number you please multiplied by one is that number. . . . Anyone who really thinks about the number *one* realizes that he cannot perceive it though the bodily senses, for whatever we experience through a sense is proven to be many, not one. . . . The order and truth of number have nothing to do with the bodily senses . . . *Scientia*, knowledge cannot be confused with *experientia*, experience" [emphasis in original].

   For succinct discussions of how Plato approaches mathematical ideas, in contrast to Piaget, see Plato's *Meno* (for a discussion of the fact that an understanding of geometrical and numerical relations stems from the *mind*); *Parmenides* (for a discussion of the notion of the one and the many); and *Timaeus* (for a discussion of the Pythagorean number scheme, intervals in a series leading to harmonic and arithmetic means, and the laws of proportion). In this last work, especially, the notion of ambiguity is important.
4. See, for example, "Teaching Geometry to Develop the Mind," an interview with FEF director of research Uwe Parpart, *Fusion*, Feb. 1980, p. 61.
5. The critical books to read in relation to this article are *The Development of Thought, Equilibration of Cognitive Structures*, Piaget; *The Origins of Intelligence in Children*, Piaget; *Mathematical Epistemology & Psychology*, Beth-Piaget; and *Readings in Applied English Linguistics*, edited by Harold Allen.

Johnny and Jane can't add because Jean Piaget's New Math prevents them from thinking.

The New Math *Destroying Cognitive Development*

by Dr. Steven Bardwell

THE MULTITUDES OF AMERICAN parents who have felt frustration and rage at what passes for mathematics in today's schools, whether they knew it or not, belong to a long line of mathematical thought stretching from the mathematicians of Plato's Academy and Archimedes, through Cusa and Leibniz, to the great 19th-century school of German and French mathematicians. This tradition is outstanding for two reasons: First, its members are responsible for every essential mathematical discovery in the last 2,000 years; second, since its inception it has been pitted against a contrary tradition in mathematical thinking, that associated with Aristotle.

The problem with the New Math goes far beyond why Johnny can't add or subtract. Indeed, the method of the New Math ensures that U.S. schoolchildren will be less able to understand or perform fruitful scientific work in general.

The New Math is not really new, any more than the inspiration for its method is new. Bertrand Russell and Jean Piaget, the modern progenitors of the New Math's ideas, both are quite explicit that their aim is to establish a non-Platonic mathematics based on the methods of Aristotle. Both make it unmistakably clear that the fundamental issue concerns how men think:

> *The "rational nature" of man is only a derivative.* The subject and object of knowledge are separate. . . . On this point as on many others, Aristotelian physics marks a return to ordinary thought rather than a continuation of the aspirations of Platonist mathematics.
>
> —Jean Piaget, *Mathematical Epistemology and Psychology*, 1966

The clearest statement of the Platonic view is perhaps given in a paper by Georg Cantor, the founder of the real theory of sets, not the so-called set theory in the New Math:

> We can speak of the reality or the existence of the whole numbers, both the finite and the infinite ones in *two* senses; however, these are the same two ways, to be sure in which any concepts or ideas can be considered. On the one hand we may regard the whole numbers as real insofar as they take up a very definite place in our mind on the basis of definitions, become clearly differentiated from all the other components of our thinking, stand in definite relations to them and thus modify the substance of mind in a definite way. Let me call this type of reality of numbers their intrasubjective or immanent reality. Then again we can ascribe reality to numbers insofar as they must be regarded as an expression or image of occurrences and relationships in the external world confronting the intellect. This second type of reality I call the *trans-subjective or transient reality of the whole numbers*. . . .
>
> There is no doubt in my mind that these two types of reality will always be found together, in the sense that a concept to be regarded as existent in the first respect will always in certain, even in infinitely many ways, possess a transient reality as well. . . .
>
> This coherence of the two realities has its true foundation in the *unity* of the *all, to which we ourselves belong as well.*
>
> —Georg Cantor, *Foundations of a General Theory of Manifolds*, 1883

This view of mathematics and science is what the New Math is designed to destroy. The Platonists have maintained that mathematics is an empirical science whose subject (like that of any science) is what Plato called the "hypothesis of the higher hypothesis" and Cantor called the "Principle of Generation," both descriptions of the self-developing evolution of the universe.

The Aristotelian opposition has counterposed the view that mathematics (along with the other sciences) is a logical structure, lacking any essential connection to reality. To the Aristotelians, mathematics is merely a product of the human mind, a mind which, in their view, itself has no essential connection to reality. (This psychology is obviously self-validating, as the insanity of many of the most illustrious in the latest generation of mathematicians is testimony.)

The fight between these two views in the 20th century has taken place over the basic concepts of arithmetic: numbers and arithmetic operations. The biggest guns of the Aristotelian faction, in fact, have been aimed at overturning the explicitly Platonic significance of the concept of number developed, as both sides recognize, by the discoverer of set theory, Georg Cantor. Bertrand Russell spent 10 years of his life producing a three-volume book, *Principia Mathematica*, which he hoped would show that mathematics could be reduced to logic *through the use of set theory*. He failed, but his book became the model

for three generations of formal logical mathematics to be used against Platonic methods in mathematics.

On the pedagogical side, Jean Piaget took Russell's work and developed a theory of number and a concept of number that he claimed purifies Cantor of his Platonic excesses!

The New Math is the fruition of the Piaget-Russell attack on Platonic mathematics. Its incoherence, self-evident sterility, and destructive effect on children's minds are not accidental. This is the essence of the Aristotelian theory of mind, and hence of mathematics.

Two Examples

Athough there have been many attacks on the New Math, its epistemological significance remains largely unknown. The destructiveness of the New Math can be seen in the two examples from the New Math curriculum that I shall discuss here. Both examples have escaped the notice of those who have criticized the New Math from conventional or practical standpoints.

The first of these is the concept of an algorithm, which is used as the basis for teaching arithmetic operations; the second is the New Math concept of the structure of the number system.

An algorithm is a set of rules, usually recursive, for performing some task and for testing for the completion of the task. The concept of an algorithm was a product of the development of machines that had to be programmed with instructions for the actions required of the machine. The punched cards that controlled early spinning and knitting machines are classic examples of an algorithm—move needle A to position 1, needle B to position 2, move the red thread over needle 1, and so on. Obviously, an algorithm is a powerful tool if certain conditions are satisfied:

(1) The problem to be solved or task to be performed is completely posed beforehand;

(2) the problem can be solved in a finite number of steps;

(3) the quality of solution does not depend on factors known only after the algorithm is begun (for example, singularities are excluded); and

(4) the rules for performing the algorithm are fixed or drawn from a fixed group.

These assumptions are fine for a machine or a computer, but they are all violated by the simplest task required of human mentation. No algorithm could be written for something as simple as getting out of bed in the morning (or getting the children off to school in the morning).

Despite this obvious fact, the algorithm has been taken as a prototype of mathematical thinking by the Aristotelians and incorporated in the New Math as the way of teaching arithmetic operations like addition and subtraction. From a psychological and pedagogical standpoint this is absurd. People are not machines; they perform tasks differently and they learn them differently.

In the same way, this method is absurd mathematically; arithmetic operations are only formally reducible to algorithmic techniques. They are actually synthetic concepts, higher-order concepts; when reduced to their algorithmic counterpart, they cease to be mathematics.

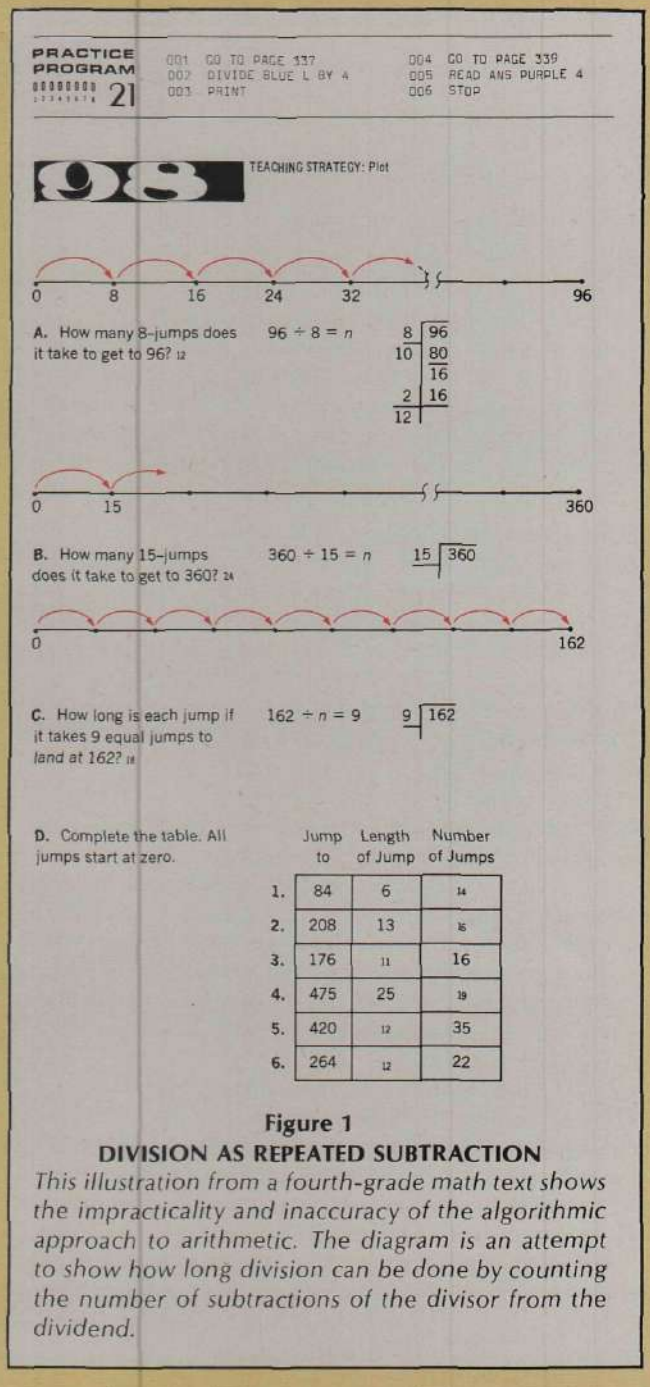


Figure 1
DIVISION AS REPEATED SUBTRACTION
This illustration from a fourth-grade math text shows the impracticality and inaccuracy of the algorithmic approach to arithmetic. The diagram is an attempt to show how long division can be done by counting the number of subtractions of the divisor from the dividend.

Long division, long the terror of elementary school students, provided fertile ground for the New Math's algorithmic theory of arithmetic. Presented with the problem of dividing 90 by 8, the New Math teacher will tell us the following (of course, the New Mathematicians probably will not do the division this way, but this is what the teacher says to the classroom):

Step 1: Is 8 larger than 90? If yes, then the quotient is 0. Otherwise go to Step 2.

Step 2: Subtract 8 from the dividend. Add 1 to the quotient.

Step 3: If 8 is larger than the dividend, then end; otherwise, go to Step 2.

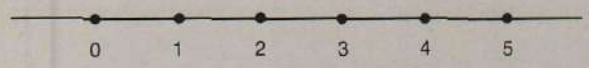


Figure 2
THE NUMBER LINE

Contrary to the implication of the New Math, the number line (the continuum) has a subtle and important structure. All numbers on the number line are not the same, and, as Cantor stressed, the generation of one kind of number from a simpler kind is a prototype not only for all mathematical reasoning but also for the evolution of the universe.

The algorithm proposed here counts the number of times that the divisor (8) can be subtracted from the dividend (90); this number of times is the quotient (11). In actuality, such a method is used only by the crudest of mechanical calculators; even computers have better ways of dividing.

Is this algorithm even division? Let's try it on the problem of 4 divided by 12. The answer, according to one New Math student, is −8.

This is certainly not the case. From a mathematical standpoint, division is qualitatively different from subtraction; it is not compounded subtraction, unless, of course, you are a mechanical calculator. Subtraction of whole numbers, no matter how many times it is performed, always produces whole numbers; but division takes whole numbers and produces a new kind of number—a rational number, or fraction. *One can never get fractions from subtraction of whole numbers.*

More Than a Mathematical Travesty

This reduction of division to an algorithm involving repeated subtraction is not merely a mathematical travesty. The subject of mathematics, as all great mathematicians have known, is not numbers and their manipulation; it is the human mind as a mirror of the universe.

Mathematics as a product of the human mind both reflects and modifies the structure and evolution of the universe. Cantor says that this connection—the "unity of the all"—*is* mathematics. Since neither the human mind nor the universe satisfies any of the four prerequisites for the applicability of an algorithm, to teach algorithmic thinking as if it were mathematics is to systematically distort both reality and human mentation.

No wonder children hate the New Math; to understand it, they must deny the fundamental characteristic of their ability to think!

Let there be no mistake; the Aristotelian faction of mathematics agrees about the implications of algorithmic thinking. They disagree only about the inapplicability of algorithmic methods to the mind and the universe. Their premise is that the laws governing both human thought and the universe are fixed. Of course, they say, algorithms work precisely because human beings and the universe are machinelike.

The problem of long division raises a more fundamental problem in arithmetic concerning the structure of the number system. The New Mathematician, of course, would deny this. In reply to my objection that the algorithm for long division could not generate fractions (because subtraction of whole numbers can generate only whole numbers) the New Mathematicians would say: We can provide you with an algorithm to calculate any division problem; you picked an algorithm that is too simple, but just because subtraction doesn't give you fractions, doesn't mean that there is no algorithm for doing so.

The real argument here is not over an algorithm for long division, but rather, over the significance of the new numbers that division generates. Any qualitative significance of division comes from its ability to generate these new numbers—fractions. The Platonic approach to mathematics has maintained, as Cantor and Dedekind were the first to show, that fractions (rational numbers) are a qualitatively different kind of number than whole numbers.

In addition, Cantor showed that the number system is, in fact, a nested hierarchy of different kinds of numbers, each of which is generated from the preceding by inherently nonalgorithmic processes like limits of infinite series. To get irrational numbers from rational ones, for example, requires a complicated geometrical argument that demands new mathematical rules for new numbers.

As Cantor pointed out, the significance of this hierarchical structure of the number system transcends its mathematical applications. It is parallel to—and a model of—the similarly nested, hierarchical structure of the physical universe. Further, Cantor showed that the fundamental feature of this hierarchy was not its structure at any one instant, but rather what he called the Principle of Generation, which creates a new level of hierarchy out of its predecessor. This transition from one level to the next (such as the transition from the whole numbers to the rational numbers) is lawful, but there is nothing in the lower level that *determines* beforehand its successor. The Principle of Generation in mathematics has been called *negentropy* in physics, but the concept is the same.

Using algorithms, bastardized set theory, and the like, the New Mathematicians deny the qualitative structure of the number system. The crux of the Aristotelian New Math approach is that the Platonic hierarchy does not exist. Russell's book was an attempt to prove the qualitative homogeneity of mathematics—to prove that it was reducible *in toto* to a fixed set of logical axioms. If Russell had been successful, it would have been possible to build a computer that could prove every existing theorem in mathematics and every theorem ever provable. He was not successful, but not because he didn't try; Russell failed because he and his New Math disciples are wrong.

The facts are that the world and the human mind are not fixed; the subject of mathematics is not logical deduction. The New Math is not just a new gimmick to teach math. It is a deliberate attempt to teach children that their minds and, indeed, the world are not capable of creative change.

Dr. Steven Bardwell is the director of plasma physics for the Fusion Energy Foundation.

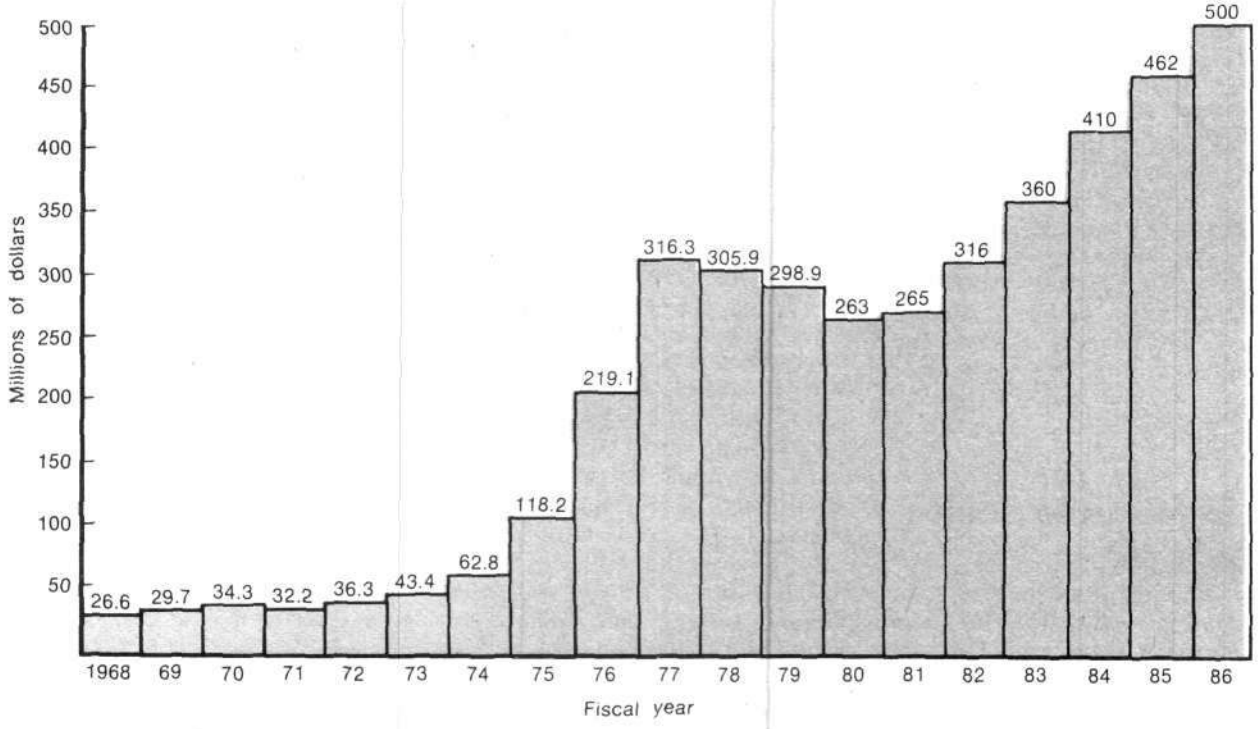
Fusion Budget Caught in Policy Fight

The delay in making key appointments in the new Department of Energy and the continuing economic fights around budget cuts within the Reagan administration have left the fusion community with only guesses as to the future of the program. Although the Magnetic Fusion Energy Engineering Act of 1980 mandates an increase in the budget for magnetic fusion of $100 million in the next two fiscal years, President Reagan's budgetary advisors are now suggesting instead that the fiscal year 1982 budget for magnetic fusion be cut.

The budget request for fiscal year 1982 from Carter's DOE of $525 million would merely have brought the program back up to its 1977 funding level of $316.3 million in real dollars, allowing for a modest 8 percent annual inflation rate since 1977. The suggested cut to $476 million would have the effect of slashing the budget to $286 million in 1977 dollars, and some Washington sources report that the administration may cut it even further. Scientists fear that such a cut would prevent the 1980 fusion legislation from being carried out.

Criticisms of a "meat axe" approach to the budget have been expressed by Republican leaders in the Senate, and Secretary of Energy Edwards has stated his support both in public and in private for the fusion effort. Therefore, the appointments made for the remaining top-level DOE posts will indicate whether the budget slashers or the promoters of economic and scientific growth will determine fusion and all energy R&D policy.

In a presentation on the magnetic fusion program to the Reagan administration's DOE transition team on Dec. 2, 1980, Edwin Kintner, director of the DOE's Office of Fusion Energy, pointed out that in addition to maintaining U.S. world leadership in this advanced technological field, fusion research is "a mechanism for advancing a number of technologies beyond their present state" and "a means to strengthen U.S. industrial innovation."



THE MAGNETIC FUSION BUDGET IN CONSTANT 1977 DOLLARS

It is an astonishing and little known fact that the magnetic fusion budget has actually suffered a decline in real dollars since the advent of the Carter administration. This is demonstrated using a rather conservative estimate of an 8 percent annual inflation rate.

The Office of Fusion Energy estimates that in order to return the program to a budget level comparable to the $316.3 million appropriated in 1977, the fiscal year 1982 appropriation would have to be $525 million. After reestablishing that funding level, a real budget of 0.5 billion dollars would be necessary by the mid-1980s.

Kintner reminded the team that the Magnetic Fusion Energy Engineering Act of 1980 is in agreement with the recommendations of three independent reviews of the magnetic fusion program made in 1980. The law mandates the demonstration of fusion's engineering feasibility in the early 1990s and the operation of a demonstration fusion power plant by the year 2000.

The Necessary Funding

Describing the present fusion program plan as "the birth of an energy technology," Kintner made clear the necessary funding profile to accomplish the tasks mandated by the law.

As the accompanying chart illustrates, the magnetic fusion budget has suffered an actual decline in real dollars during the Carter years, using the conservative estimate of an 8 percent annual inflation rate. The requested 28 percent increase to $525 million will ensure the budget level to enhance the program by restoring the contraction from the four previous years.

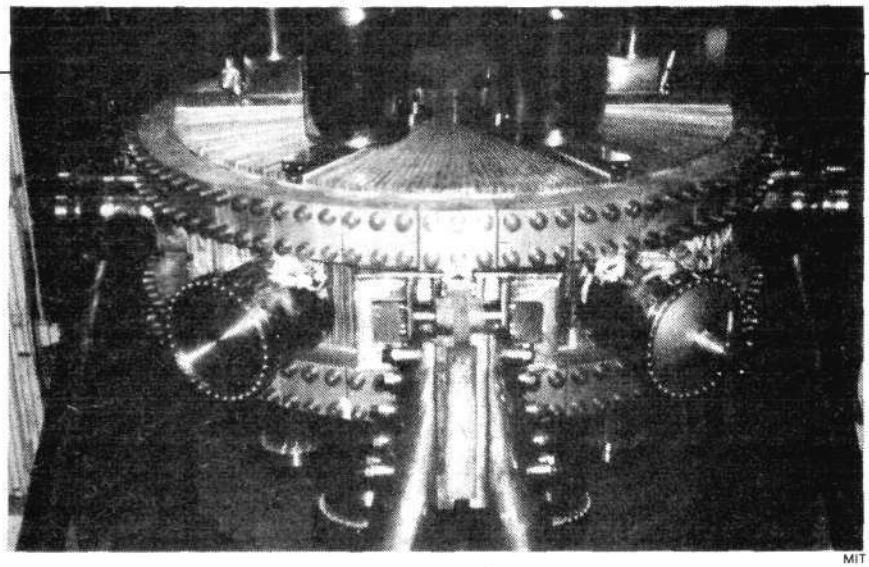
As fusion scientists have pointed out, the $60 million cut from President Ford's recommended fusion budget for fiscal year 1978 when Carter took over has had a long-term negative effect. The fusion community had hoped that the fusion law would ensure that this be reversed, and are watching the DOE appointments and budget battles with close attention.

—Marsha Freeman

Lubin Moves to Sohio

Dr. Moshe Lubin, a pioneer in laser fusion and director of the University of Rochester's Laboratory for Laser Energetics, has been appointed vice president of Standard Oil of Ohio (Sohio). Lubin will direct Sohio's research and development projects.

Dr. Jay M. Eastman, Lubin's deputy director at Rochester, will be taking over as acting director of the Laboratory for Laser Energetics. The laboratory, which is the only major U.S. fusion facility not located at a national laboratory, had been directed by Lubin since its inception in 1974.



MIT

The projected fusion budget cuts would delay the ongoing programs at national laboratories. Here, the Alcator, a small pace-setting tokamak at the Massachusetts Institute of Technology, which has achieved reactor-level density and confinement times.

FPCC Meeting Plans Fusion Course

The Fusion Power Coordinating Committee, an advisory group to the DOE fusion director that includes representatives of the Department of Energy, the national fusion laboratories, and industry, met Dec. 9-11 in Oak Ridge, Tenn., to discuss the current status of the U.S. magnetic fusion program and how the Magnetic Fusion Energy Engineering Act of 1980 should be implemented.

Representatives of the DOE's Office of Fusion Energy presented detailed plans for the program required to fulfill the mandate of the McCormack fusion bill, which has as its goal the construction of a prototype fusion electric power plant by the year 2000.

Dr. Michael Roberts, director of planning and projects for the Office of Fusion Energy, laid out the schedule for the Center for Fusion Engineering (CFE) mandated in the law. He discussed the details of how the cooperation among industry, universities, the national laboratories, and the DOE necessary to plan and build the CFE would be coordinated, with near-, mid-, and long-term program strategy planning.

A manpower requirement study for the CFE is now underway and should be completed by the end of 1981. A further study is being made on how international collaboration should be enlisted for the development of this new, crucial fusion facility. Alternate designs for the CFE should be completed within one year, with an industrial contractor chosen within the months following design acceptance.

Planning the FED

The Center for Fusion Engineering will have as a primary objective the construction of the McCormack bill's mandated Fusion Engineering Device (FED) by 1990. Dr. John F. Clarke of the Office of Fusion Energy reported on progress in planning this facility. The initial design has begun, and a final design concept will be chosen by the fall of this year.

Clarke discussed in detail the goals of the FED and how they would be reached. The FED will be constructed to achieve a reliable, sustained level of energy production and extraction, on the basis of an integrated set of engineering systems that can be extrapolated to a fusion demonstration plant.

In addition, supplementary engineering demonstrations will be performed, as required by the problems encountered in achieving sustained energy levels. These will include stud-

ies of the materials and blankets needed to withstand the high neutron flux of the FED, long-term fatigue tests, and special technologies required for nontokamak plasma diverters.

The FED parameters currently projected are an operating temperature of 110 million degrees Celsius (10 keV), a density of 78 trillion ions per cubic centimeter, and a confinement time of 1.4 seconds.

Plasma currents up to 6.3 million amperes with average plasma betas of 6 percent (beta is the ratio of the plasma pressure to the strength of the confining magnetic pressure) are also planned.

Other sessions at the FPCC meeting reviewed the experimental and theoretical fusion programs of Oak Ridge National Laboratory and the present status of the tokamak in the overall national fusion effort.

Oak Ridge reported that work on the Elmo Bumpy Torus, an alternative magnetic confinement device, is proceeding on schedule. McDonnell Douglas Corporation was awarded the DOE contract to design and construct a proof-of-principle Elmo Bumpy Torus in Sept. 1980, and the device is planned for a 1985 completion date.

LLNL to Replace Argus with Novette

The Laser Program of Lawrence Livermore Natioal Laboratory in California has begun to replace its Argus laser system with Novette, a full-scale mockup for Nova. The Argus laser system, which was the two-beam model for the existing 20-beam Shiva laser fusion facility, has been the workhorse for LLNL's basic experimental physics program.

Besides demonstrating the laser technology for Nova, the more advanced laser fusion research facility now under construction, Novette will continue the important basic physics work of Argus, particularly with shorter-wavelength light.

Whereas Shiva now attains bursts of laser output at 30 trillion watts, the full 20-beam Nova will increase this 10-fold to 300 trillion watts! At such power levels, Nova will demonstrate the scientific feasibility of producing laser fusion energy sometime in the late 1980s.

U.S. Committed to Intor's Next Stage

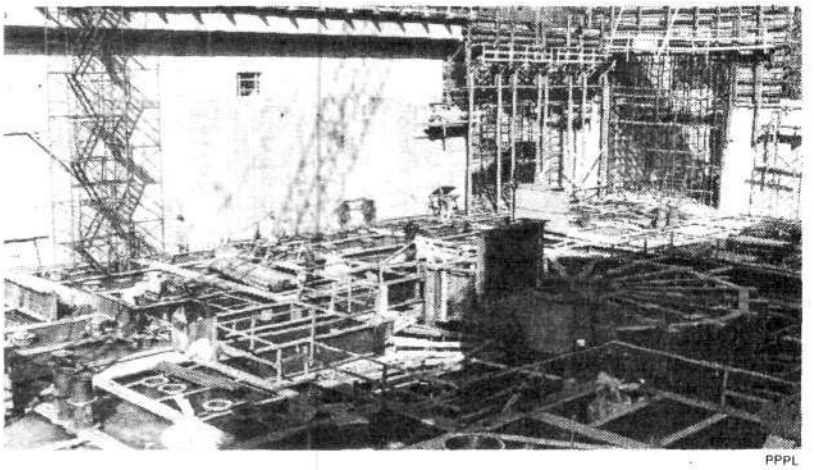
The United States has committed itself to negotiations for the next detailed planning stage of Intor, the prototype tokamak fusion reactor of the International Atomic Energy Agency, according to DOE sources. The same sources report that the Soviet Union has also indicated its willingness to discuss the next step.

Intor was originally proposed by the Soviet Union as a huge, reactor-scale tokamak to be built as an international project under the auspices of the International Atomic Energy Agency. Although international conditions have caused pessimism over Intor's future, the project has remained active and is proceeding on schedule in the planning stage.

There are also indications that Soviet opposition to building the Intor in West Germany—the most feasible location outside the Soviet Union in terms of technical resources—has begun to dissolve.

Dr. Melvin Gottlieb, who recently retired as director of the Princeton Plasma Physics Laboratory, noted in a Feb. 6 press conference at Fusion Energy Foundation headquarters that all the Intor participants—the United States, the Soviet Union, the European Community, and Japan—had "gained mightily from this international cooperative effort" and "had learned from one another."

"The international group," Gottlieb said, "was not sure the United States would go ahead with a vigorous fusion program." But if we would, he continued, "we'd be a big jump ahead."



PPPL

TFTR Generator Damaged

A large flywheel-motor generator to be used in the second power supply unit of Princeton Plasma Physics Laboratory's Tokamak Fusion Test Reactor was damaged in January when a crane moving it into place failed and dropped the assembly. The Tokamak Fusion Test Reactor has been nearing completion, which is scheduled for early 1982. Since the schedule did not call for utilization of the second power supply until 1984, this accident need not delay the actual TFTR plans if sufficient funds are made available to initiate repair and replacement immediately. Shown here is the construction site in Feb. 1980.

New Evidence That Nuclei Have Crystalline Structures

A research team in Alma Ata, the capital of Kazakstan, has reported experimental evidence that atomic nuclei have crystalline structure.[1] If their findings are borne out, it may be necessary to reevaluate the basic concepts behind the current understanding of nuclear structure.

With the exception of several distinctly minority speculations in recent years, most scientific opinion holds that nuclei are spherical or spheroidal. All theories of nuclear structure start from this premise, drawing heavily on it to reach conclusions about the measured properties of nuclei as small as deuterium and as large as the transuranic isotopes.

The Alma Ata results are experimentally equivalent to X-ray crystallography. In the X-ray experiments, crystals are bombarded with X-rays of known wavelengths. The scattered X-rays fall on a photographic plate or other appropriate detector. The experimenter analyzes the distribution of X-rays scattered at different angles and from this information infers the shape of the crystal lattice and the spacing between atoms. X-rays are used for this because their wavelengths are comparable to the spacing between atoms in a crystal and can thus resolve some of the detail of that structure. Visible light is unsuitable because its wavelengths are thousands of times the atomic dimensions.

To perform a similar experiment to detect nuclear crystalline structure requires that the particles bombarding the nuclei have wavelengths comparable to nuclear crystalline dimensions, about 10^{-15} meters. Alpha particles in the 30 to 50 MeV (million electron volt) energy range, available from the particle accelerator in Alma Ata, meet this requirement.

By careful measurement of the alpha particle scattering from nuclei that were polarized by the scattering process, Pavlova *et al.* detected significant deviations from the pattern that would be expected from nuclei that had no internal structure. When the Soviet group did the same experiment on nuclei that were not polarized, the structure information was absent, as would be expected.

The Uncertainty Principle

Probably the most startling result of this experiment is that it may point to the breakdown of one of the fundamental laws of quantum mechanics. According to Heisenberg's uncertainty principle, the greater the degree to which an object is localized in space, the greater is the range of the uncertainty with which its momentum can be specified. For localization of protons and neutrons in a nuclear crystal lattice, the uncertainty in their momentum implies that they should be able to break free from the force binding them in the nucleus. In fact, they should be able to attain energies nearly 10 times the energy that binds them. If both the uncertainty principle and these experimental results were true, there could not be any stable nuclei.

If the crystalline model were taken seriously, but naively, one would imagine the different nuclear isotopes to be constructed simply by piling up neutrons and protons in a lattice array. Such a conception, however, ignores the fact that the protons and neutrons are themselves modified as they become part of a nucleus.

The clearest evidence for this is that the mass of a nucleus is measurably less than that of the nucleons (protons and neutrons) that go into its construction. On the other hand, there is evidence that some properties of the nucleons—e.g., the charge of the protons—are preserved to a high degree when they are bound in nuclei.

A recent theoretical paper by Norman D. Cook on crystalline nuclei leads to some intriguing predictions that concur with observed nuclear properties.[2] Cook proposes that alternating layers of neutrons and protons can be built up to form octahedral crystals.

The packing in this arrangement coheres with a property of nuclei known as magic numbers. It was discovered many years ago that isotopes that contained certain numbers (2, 8, 20, 50, 82, and 126) of neutrons or protons were particularly tightly bound compared to other nuclei near them. In the crystalline model, these numbers correspond to crystals that are perfectly octahedral, with no excess or shortage of nucleons.

Since nuclear fission was discovered in 1939, the dominant model to describe it has involved a picture of the nucleus as a droplet of liquid, with the nucleons taking the part of molecules moving freely through the droplet. A neutron is supposed to enter the droplet, exciting vibrations in it and sometimes causing it to deform sufficiently that its surface tension is no longer able to keep it from splitting. According to this model, the droplet should break into two pieces of nearly the same size. Real nuclei, however, tend to fission into two pieces of substantially different size.

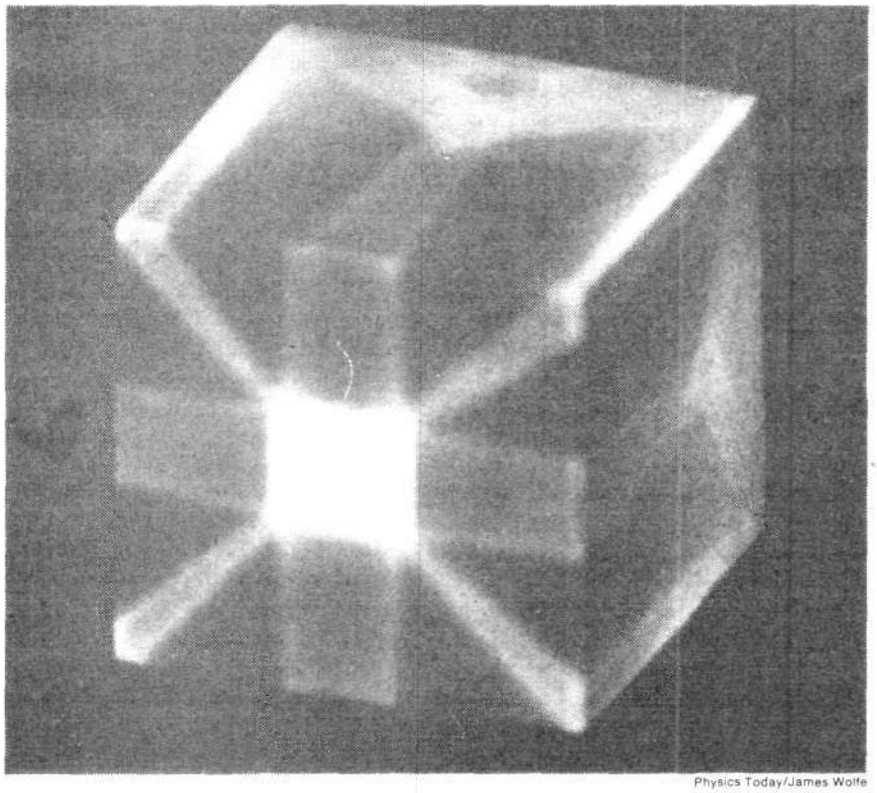
If the nuclei are, in fact, crystalline, this could be more easily understood. The incident neutron's role is not to excite vibrations in a droplet, then, but to cleave a crystal along a plane. More often than not, this could lead to unequal sizes for the fission products, since relatively few cleavage planes halve a crystal.

The new experimental evidence indicating the crystalline structure of nuclei raises some interesting questions for future exploration as well as for the reinterpretation of known results. For example, what are the kinds of phase transitions that can occur in nuclei? We know that crystalline carbon in the form of graphite changes its crystal structure and becomes diamond under the right temperature and pressure conditions. Can similar transitions be found in nuclei?

—Dr. John Schoonover

Notes

1. N. N. Pavlova, A. M. Ivanov, A. V. Yushkov, and K. A. Toktorov. 1979. *Bulletin of the USSR Academy of Sciences*, 43, p. 2317.
2. Norman D. Cook. 1976. *Atomkernenergie*, 28, pp. 195-199.



Physics Today/James Wolfe

Heat energy propagating like a beam of light from a point on the back surface of a 1.9-K, 1-cm³ germanium crystal.

The Dynamics of Heat Conduction

A New Look at the Crystal Lattice

Crystalline systems, with their high degree of symmetry and seemingly restricted set of interactions, have always been considered the simplest examples of continuum dynamics for sound waves, heat propagation, electrical conduction, and the like.

Over the last 15 years, however, some extraordinarily beautiful new experimental results (summarized in the Dec. 1980 issue of *Physics Today*) show that even in this simplest of systems, the primary feature is *not* the particles that make up the crystal, or even their low-energy interactions. Rather, the primary feature is a higher-order geometry of the crystal that defines an increasingly complex set of singularities as the crystal increases its energy density.

Traditional wisdom had held that the energy exchanges between atoms in the crystal lattice were random, thermal vibrations. This theoretical view was sufficient to describe in quantitative terms the conduction of heat, the properties of a collection of random acoustic waves, and the gross properties of crystalline energy containment.

However, in 1964 at the IBM Laboratory in Yorktown Heights, N.Y. and shortly thereafter at laboratories at a number of universities, it was discovered that the actual dynamics of heat conduction (energy transfer) in crystalline structures are neither random, thermal, nor, in fact, even a smooth, continuous process.

These experimental results, which have caught the interest of a large number of physicists and engineers, show that under carefully controlled conditions, the actual "microscopic" process of heat transfer can be measured.

In the simplest of these experiments, a single crystal of germanium is cooled to near absolute zero, where the background thermal (vibratory) motion of the crystal lattice is very small. Using very delicate temperature-measuring devices, the reaction of the crystal to a small heat pulse is measured.

Contrary to intuition, the crystal does not heat up uniformly. Instead, the heat travels through the crystal in an ordered pattern, very similar to that of a light beam in an optical medium. The heat beam can be focused, diffracted, and reflected just like a beam of light! Pictures of this heat beam propagation have been taken that show the energy bouncing back and forth through the crystal like light in a box of mirrors.

The mathematical analysis of this unexpected beam propagation phenomenon has raised fundamental questions about what a crystal is really made of. If the crystal is mathematically described as an interconnected set of springs and balls (a linear harmonic oscillator connected in a three-dimensional lattice), many of these phenomena can be described.

The mathematical methods used point to a much more fundamental feature of the system: Namely, the crystal is really made up of a set of successive levels of singularities that are, in fact, responsible for the existence of the crystal in the form of a lattice of particles.

In other words, heat propagates along optical paths because of singularities in the function that describes the elastic response of the crystal. Precisely at the infinities of this function, the heat is concentrated.

The usual interpretation of this fact, however, misses the basic point: These singularities are what is primary; the singularities make a crystal what it is, not the collection of atoms whose configuration results as well from these singularities. This succession of singularities prescribes the existence, form, and stability of the lattices that can exist.

—Dr. Steven Bardwell

Industrially Caused Cancers 'Exaggerated'

Dr. Michael B. Shimkin, professor of oncology and community medicine at the University of California-San Diego, stated at an international cancer symposium that "studies on the incidence and mortality in human populations do not support an important role for industrial carcinogens in the total cancer occurrence."

Shimkin singled out tobacco use as the most important cause of cancer in the United States and estimated that the elimination of smoking would diminish the number of cancer cases by more than 100,000 annually. Among other suggestions to lessen the incidence of cancer, Shimkin cited not drinking excess amounts of alcohol, following a prudent diet, avoiding unnecessary X-rays, avoiding excessive sun exposure, and avoiding inappropriate drugs.

Another study on the relationship of smoking to cancer strongly suggests that the effects of smoking are not limited to smokers alone, but are highly deleterious to nonsmokers as well. The study, conducted by the National Cancer Center Research Institute in Tokyo, Japan, showed that the wives of smokers were up to two

times as likely to get lung cancer as the wives of nonsmokers and that the increased risk to the "passive" smoker is directly related to the extent of smoking by the spouse.

Insulin Found Safe In Human Tests

Results from tests on volunteers indicate that the products of genetic engineering are safe and effective for humans.

Medical researchers at Guy's Hospital in London, England compared insulin manufactured by bacteria genetically engineered with recombinant DNA techniques to the commercial insulin obtained from swine or cattle, using a group of 17 healthy males.

As reported in the medical journal *Lancet*, "The experiments described in this paper report, not only the first use of human insulin produced by recombinant DNA, but also, to our knowledge, the first use of any recombinant DNA product in man. . . . *In neither this nor our subsequent* experiments were there any indications of short-term adverse effects. Longer term studies, particularly in respect of immune responses, are clearly of major importance and are in progress."

Gene Transplant in Mice

The potential for profound advances in basic research in the area of genetics has been significantly advanced by the successes in the laboratory of Dr. Francis Ruddle of Yale University.

Ruddle and his colleagues, Doctors Gordon and Scangos, announced at a meeting in West Berlin that they have been able to inject foreign genes—in this case those of a genetically engineered hybrid virus—into a newly fertilized mouse egg (or zygote) and implant this zygote into a recipient female (mother-to-be). They then determined that the cells of the developed organism had incorporated the virus's genetic material into their own.

Among the immediate possibilities for further research are insights into the factors that control the functioning and modifications of the genetic material, the locations of various genes that are incorporated by the host animal, and the factors that control this incorporation. In the longer term, this technique holds potential for the deliberate intervention into the abnormal functioning that occurs in genetic diseases and the alteration of an animal's fundmental genetic composition for improved species for plant and livestock production.

Report Finds Lower Risk from Radiation

A report released by the National Research Council Committee on the Biological Effects of Ionizing Radiation (BEIR) substantially reduces the estimates of the human cancer risks from radiation exposure. The report projects rates approximately one-half those estimated eight years ago in its last report. The new study was conducted in response to an Environmental Protection Agency request to evaluate health effects on human populations from radiation exposure.

The basis of the lowered estimates lies in the increased capability of researchers to use dose-response models with which to calculate the greatly increased scientific information available, particularly human epidemiological studies and radiobiologic knowledge. The committee considered the linear-quadratic dose-response model the most practical; this model gives results for low levels of radiation (the usual situation) to be much lower than would be expected if one were to linearly extrapolate the experimentally obtained cancers resulting from high-dose radiation exposures.

FEF Tribute to Gottlieb:

'An Authentic American Hero'

More than 350 fusion supporters gathered at a banquet sponsored by the Fusion Energy Foundation Feb. 6 at New York's Hotel Biltmore to honor Dr. Melvin B. Gottlieb, who recently retired as the director of the Princeton Plasma Physics Laboratory.

The program, titled "Fusion: 50 Years of Progress," paid tribute to Gottlieb's 25 years in fusion and his leadership of the nation's pace-setting tokamak program at Princeton.

On hand to recount the history of the fusion program and Gottlieb's pioneer role were three generations of fusion scientists—including Gottlieb's college physics teacher, Dr. Robert Moon, professor emeritus of physics at the University of Chicago, and one of Gottlieb's former graduate students, Dr. William Ellis, director of the Mirror Systems Division at the Department of Energy Office of Fusion Energy.

Other speakers were Leonard F.C. Reichle, executive vice president of Ebasco Services, Inc., the engineering firm that is constructing the TFTR tokamak at Princeton, and Boris Kouvshinnikov, the representative in New York of the director general of the International Atomic Energy Agency. Reichle, one of the members of the FEF banquet committee, made the surprise announcement that Ebasco had just established a $10,000 scholarship in Gottlieb's name at the Polytechnic Institute of New York.

Dr. Morris Levitt, executive director of the Fusion Energy Foundation and master of ceremonies, also read several messages from well-wishers who were unable to attend—New Jersey legislators and congressmen, Rep. McCormack, and several leading scientists, including the heads of three fusion programs at national laboratories.

The Fusion Budget Fight

As the speakers lauded Gottlieb's efforts in the scientific and political fight over the years to ensure the benefits of fusion power by the 21st century, it was made clear that this fight is far from over. Rep. Mike McCormack, the man who initiated the 1980 fusion legislation, put it this way in his written tribute to Gottlieb: "Even as you read this, we are entering upon a new struggle to obtain recognition of the importance of full funding for the program.

"Any suggestion that the federal budget be cut below $525 million for fiscal 1982 must be met with overwhelming pressure from all walks of American life, with the result that the administration and the Congress will acknowledge the broad base of public support for moving forward aggressively with our magnetic fusion engineering and development program and with the political necessity of funding it at appropriate levels."

Stuart Lewis/NSIPS

"Fusion: 50 Years of Progress." Above: Dr. Mel Gottlieb at the podium; to his left are FEF research director Uwe Parpart, Mrs. Parpart, and Dr. Robert Moon. Below: Leonard F.C. Reichle (left) and Dr. Morris Levitt.

Stuart Lewis/NSIPS

Dr. William Ellis: "Mel, thank you for helping us plant a tree."

As Gottlieb later noted, the 350 persons attending the dinner were testimony to the ability of the FEF to organize just that kind of broadbased support for the fusion program. "This banquet is but a small part of what the FEF has done," Gottlieb said. "The FEF did a simply magnificent job providing support to get Congress to act [to pass the fusion legislation]. The FEF has provided real leadership in educating the public, Congress, and scientists in other disciplines about fusion." Gottlieb called the Magnetic Fusion Energy Engineering Act of 1980 "the turning point in the history of fusion. At last fusion is recognized as something with real promise—an energy option instead of just a research program."

For the FEF, the event was also a turning point: it marked the first time that individual *Fusion* readers and FEF members were joined at a major event in support of the fusion program by official representatives of the nuclear industry, the Princeton fusion program, labor unions, the Department of Energy, the IAEA, local legislators, and several high-technology companies.

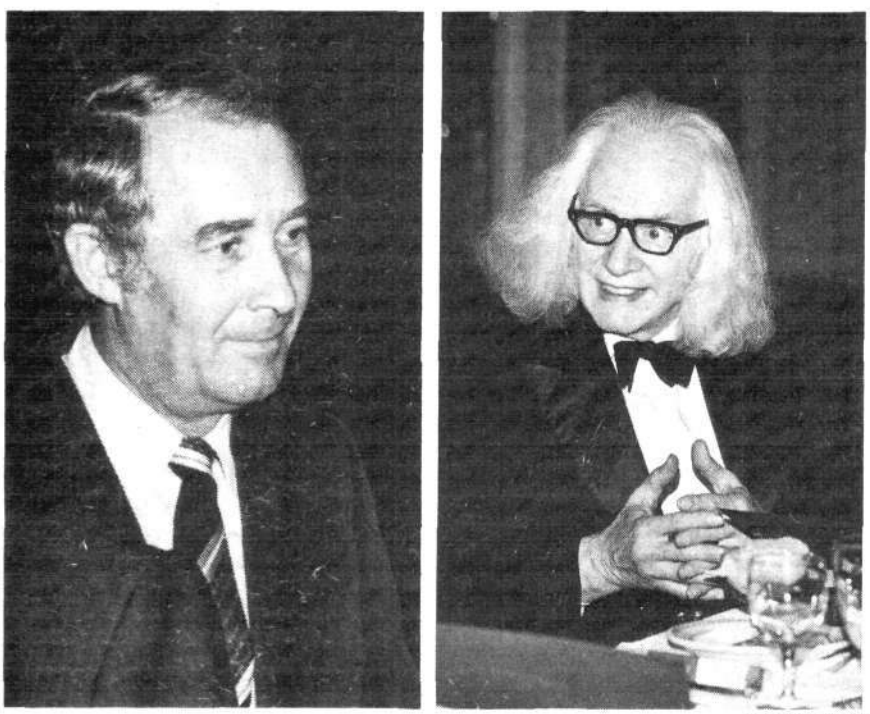
"This is the kind of political muscle we need," Levitt said, "to ensure that we turn the mandate of the 1980 fusion legislation—a prototype fusion reactor by the year 2000—into a reality."

The program honoring Gottlieb was planned as a celebration of American science. "Since great music and great science have always gone hand in hand in uplifting populations," Levitt said, "it is appropriate to start the evening with some great music." He introduced a string quartet from the Platonic Humanist Academy, who then played Mozart's Adagio and Fugue.

"Mel Gottlieb is an authentic American hero," Levitt said in his opening remarks. "He's a person whose life's work demonstrates that there is a solution to the energy crisis if we permit scientific effort and ingenuity to flourish."

"Although the fusion program is not as well known to the public as the Manhattan Project or the Apollo program," Levitt said, "it is certainly the most important scientific and technological endeavor the country has ever made and it is enormously successful in the face of adversity. . . . Mel Gottlieb typifies those scientists who have worked quietly and persistently to bring us to the goal of achieving this abundant energy source."

Dr. Moon spoke next, relating vignettes of Gottlieb's work on the University of Chicago's first cyclotron during the 1930s, when they couldn't afford $2,000 to put the magnet together and had to do it by hand. Moon, who is a founding member of



Stuart Lewis/NSIPS

Boris Kouvshinnikov (left): "Mel has the thanks of the international scientific community for his work." Dr. Robert Moon: "Mel has demonstrated that we're ready for fusion energy."

the Fusion Energy Foundation, also described his ideas about fusion in the late 1920s. "The journals of the time," he said, "were already lamenting that by the end of the century the U.S. would run out of liquid fuel and wondering what to do about it." Moon's first choice for a doctoral thesis was the topic fusion.

"There are two different kinds of time," Moon said in conclusion, "*chronos*, which is clock time, and *kyrios*, which is God's time. The time in both senses has come. Mel has demonstrated that we're ready for fusion energy. . . . In heating a plasma to millions of degrees, he asked nature what it would do. . . . It set the world on fire, and gave us a great hope."

Dr. William Ellis, who spoke next, noted that his fusion career started 20 years ago when he took a graduate course in plasma physics with Gottlieb. "To give you an idea of how long ago that was," Ellis said, "Mel could teach a whole semester on plasma physics without ever mentioning the word tokamak."

Ellis then discussed the recent history of the fusion program and "Mel's work in the trenches," his "vision" in understanding what his work meant for the future, and his "political will" to get the job done.

Ellis told the story of Gen. de Gaulle's gardener who hesitated in planting a tree that would take 100 years to grow to maturity. " 'Start planting,' de Gaulle said, 'because in that case, we haven't a moment to lose.' "

"Mel, thank you for helping us plant a tree," Ellis concluded.

Policy Questions

Earlier the same day at FEF headquarters, Gottlieb gave a press conference on the future of the fusion program and the budget decisions facing the new Reagan administration. "When one looks for portents, the only thing I think one can say is that the administration has been speaking favorably about the importance of research and applied research. From that policy standpoint one would expect to emerge a favorable view. Of course the budget pressures [to cut] are also working, and in the opposite direction."

Asked by the *New York Times* science editor Walter Sullivan whether the fusion program could sustain a 10 percent cut, Gottlieb called such a cut "a serious error" and explained how it would delay the program and dissipate the necessary skilled labor force.

Excerpts from Dr. Gottlieb's remarks appear in the Viewpoint section of this issue.

—Marjorie Hecht

Kepler Vs. Newton:
FEF Tour Stirs W. German Universities

"The pictures of Saturn disprove schoolbook physics: Kepler was right; Newton was wrong. . . ."

With agitational handbills heralding his arrival, Dr. Jonathan Tennenbaum, director of the Fusion Energy Forum of West Germany, drew audiences averaging 200 persons in 10 cities across Germany in January to his slide show and lecture on the challenge of the Saturn results.

Among the stops on Tennenbaum's tour were: Munich, where he lectured at the Deutsche Museum, the world-renowned science museum; Karlsruhe, site of a major nuclear research facility; the university town of Stuttgart; Mainz; Düsseldorf; Aachen; Münster; and Duisburg.

Tennenbaum's lectures focused on the fact that the phenomena observed by NASA's Voyager 1, such as the braided F ring, could not be explained by existing theories of Newtonian celestial mechanics and rightly challenge science to adopt a theoretical framework that views Saturn and other planetary systems as part of a self-developing, negentropic universe. Tennenbaum's insistence that Newton and the Second Law of Thermodynamics have to be overthrown in order to account for the celestial phenomena transmitted by Voyager generated lively controversy at the forums.

The 'Small' Opposition

The FEF lecture tour is also serving to flush out the opponents of scientific progress in West Germany in the universities, as well as in the environmentalist movement. In the city of Duisburg, Greenies put out a leaflet denouncing the Fusion Energy Forum, claiming that nuclear energy is fascist, and they pressured the university to cancel the forum.

Thanks to the publicity, it had to be rescheduled at a larger lecture hall.

At the University of Münster, the head of the astronomy department, a Professor Setter, peremptorily canceled the scheduled forum, and the 150 students who arrived to hear Tennenbaum found the door to the lecture room locked. The FEF countered by issuing a leaflet on the treatment of Galileo by the Jesuit Counterreformation and people who look through the wrong end of telescopes.

Two days later Professor Setter was forced to give her own lecture on man's exploration of space, which was attended by only 40 persons. The theme of the lecture was "the greatness of man is to have realized how small he is."

Bienvenue!
Fusion in French

February marked the debut of the FEF's first French language publication, *La Lettre de la Fusion*, an eight-page, monthly newsletter, which plans to expand into a major magazine as soon as sufficient funds and collaborators are secured.

In a page-one editorial, "In defense of science and progress," editor-in-chief Laurent Rosenfeld explained the reasons for launching the publication at this time, in a country with the most ambitious nuclear program in the West. Despite the majority senti-

ments in France in favor of nuclear energy and scientific development, Rosenfeld wrote, the campaigns of the environmentalists have not been without their effects; France's science magazines have become a curious mixture of scientific and antiprogress statements. "In launching *La Lettre de la Fusion*, we intend to revive the love of science and to promote scientific research and technological development," Rosenfeld stated

The first issue features articles on the significant advances in inertial confinement laser fusion coming out of the Ecole Polytechnique Laboratories in Palaiseau near Paris, the passage of the McCormack fusion bill in the United States and its potential for enhancing European fusion research, and the revolution in scientific thinking demanded by the Saturn results.

The English language *Fusion* magazine has enjoyed a very strong following among French government, business, and scientific circles during the last several years. The decisions to launch the French publication and to hold a series of national conferences over the next year were taken to increase the FEF's institutional presence in France.


La Lettre de la
FUSION
En défense de la science et du progrès
Au sommaire

La Lettre de la Fusion: "We intend to revive the love of science."

FEF's Pollak Routs Environmentalists in Mexico

"I try to teach my students that human beings are qualitatively different from animals, but they seem unable to comprehend this. I felt I was alone until I heard your talk."

This remark from a college instructor at Mexico's Polytechnique Institute to Dr. Richard Pollak, *Fusion*'s biology editor, summed up the profound impact of the FEF and AMEF (Mexican Association for Fusion Energy) presence at the institute's Dec. 8-12 conference on "Problems of the Environment Under Man's Control."

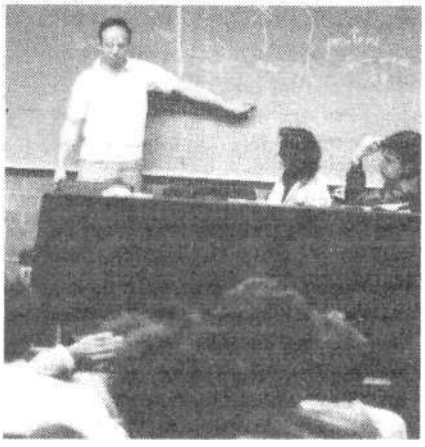
The Mexico City conference was an international event, attended by about 400 Polytechnique students and faculty members and addressed by speakers from government ministries and industry, as well as professors and graduate students of the institute. The AMEF was invited in response to its growing visibility as a force for science and technology within Mexico.

Although the stated purpose of the conference was to explore the environmental problems facing Mexico, it was clear from the agenda that some conference planners hoped to convince the audience that Mexico's strong commitment to development through science and technology should be abandoned.

Had it not been for the presence of Pollak and two members of AMEF, Dr. Luis Abreu and Mrs. Delia Araujo, the neo-Malthusians would have enjoyed considerable success in their efforts to recruit students and faculty into Mexico's fledgling environmentalist movement. But the FEF-AMEF presence was felt throughout the conference. By the time Pollak spoke on the next to last day of the conference, he already enjoyed considerable notoriety based on his polemical refutation of a leading professor's attack on the supposed dangers of DDT.

Self-Identity

In his presentation on the second day of the conference, Dr. Luis Abreu from AMEF posed for the students the question each individual in society must answer: that of one's self-conception. Did they identify themselves as creative individuals who must develop the political and scientific-technological solutions to the problems of maximizing development, and thereby solve the true environmental problems associated with insufficient creation of societal wealth? Or did they see themselves as "one-with-nature" beasts, the identity put forward by the zero-growthers?



Pollak teaching recombinant DNA to conference participants.

Abreu's provocative talk was followed by Mrs. Delia Araujo from AMEF, who analyzed the energetics of agricultural production in Mexico. Demonstrating empirically that the truly energy-conserving methods in agriculture are those that maximize energy throughput, she proved that the most energy-intensive methods involving capital-intensive mechanization, irrigation, and fertilization techniques are the most efficient and valuable for the Mexican economy and environment.

Pollak's speech on Dec. 11 was one of the best attended conference sessions, with more than 200 present. Emphasizing that the universe is fundamentally negentropic, Pollak used biological examples to show how

continued qualitative and quantitative increases in energy throughput are apparent in the continued self-development of the biosphere. This is scientifically coherent with a concept of negentropy that defines energy as input being self-organized into higher states of quality of energy input, embodying an image of self-transformation of energetic processes.

Using this principle as the scientific basis for evaluating environmental problems, Pollak told the audience: "The true dangers to the environment lie in the proliferation of drugs, rock music, and environmentalism. . . . Each of these negates the true quality of humanity—the creativity of mind—and it is this creativity that is responsible for the continued development of the universe."

Man or Beast?

The question period and the round table discussion following it were predictably stormy. Most of the questions were addressed to Abreu and Pollak, with audience comments ranging from attacks on Pollak's criticism of Darwin to a defense of China as the model Mexico should follow for development.

It became clear that the audience was emphatically polarized. About one-third agreed with the environmentalist professors, who at this point modified their initial rabid neo-Malthusian position to approve of "appropriate technology"—calling for native and thus "appropriate" technology to be implemented at minimal rates. The majority, however, opposed the unscientific position of the environmentalists, and many attended a biology seminar given by Pollak the day after the conference ended.

The next major AMEF event will present the alternative to Malthusian economics for Mexico. On Feb. 19 and 20, AMEF and the FEF will hold a seminar on economic planning in Mexico between now and the year 2000 at the prestigious Mexican Petroleum Institute in Mexico City. The centerpiece will be the unveiling of AMEF's development program for Mexico, using the LaRouche-Riemann econometric model.

Coming in The Young Scientist

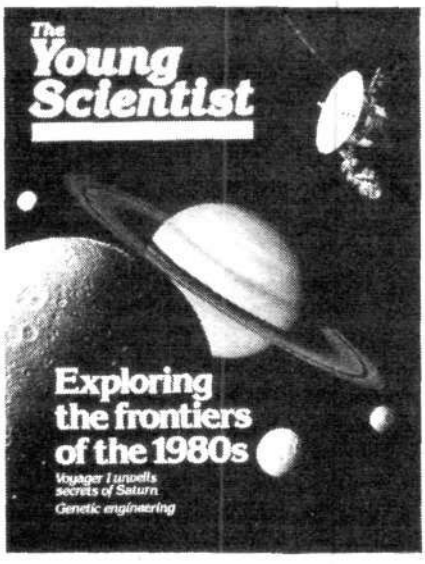
The Fusion Energy Foundation's new children's science magazine, *The Young Scientist*, has expanded to 26 pages in the Feb./March 1981 issue.

Spectacular color photos of Saturn accompany an exciting analysis of the 1980 Voyager 1 exploration of Saturn, teaching how the scientific method of Kepler is needed to analyze the data provided on the complex Saturnian system.

The feature article by Dr. Richard Pollak then takes the reader on a tour of genetic engineering, starting with the ABCs of genes and DNA, to give a full understanding of how this new science will cure disease and make barren planets earthlike.

Other articles include the latest scientific news on superconductors, radio telescopes, the decline in science education, the Soviet record of six months in space, and a new vaccine for hepatitis, with enough explanation for the beginning scientist to consider the important questions raised.

In the regular departments, Professor Von Puzzle describes a very strange ant race (and gives the answers to the last issue's puzzles), while the world of robotics is explored in Science on Tour. A deceptively simple experiment with a drop of oil opens up the science of hydrodynamics in the Experiments section, and a genetic engineer talks about her work in biology in the Interview.



In Tales of Science, Samuel Morse finishes his story of the Morse code and the Atlantic Cable, while cartoon character Pete Progress uses his page to help a friend cope with the trials of the simple life.

Subscription Information

If you haven't subscribed to *The Young Scientist* yet, send $8 for five issues to the Fusion Energy Foundation, or join the Young Scientist Club for $25. Information on the corporate sponsorship program and bulk subscriptions is available upon request.

100 FEF Members View Saturn Slides At Boston Event

Members at a Fusion Energy Foundation dinner in Newton, Mass. Jan. 27 viewed the spectacular photographs of Saturn sent back by Voyager 1 and listened to a moving presentation by FEF research director Uwe Parpart on the possibilities before man of colonizing the galaxy and "filling the universe with human intelligence." Parpart described the excitement of being alive and of being a scientist at this particular juncture in history, when we stand on the threshold of so many scientific and social breakthroughs.

The dinner, held in this center of the electronics and aerospace industry near Boston, drew an audience of 100, which included area engineers, corporate executives, military personnel, physicians, and other professionals. A local metallurgist provided gifts for all—coffee mugs decorated with a green heart with "Seabrook" and "Nuclear Power for New England" written across them.

A *Young Scientist* display, where two young scientists conducted soap bubble experiments, was a center of attraction at the dinner. New England's thriving Young Scientist Club was launched last Christmas with a

FEF in the News

Grants [N.M.] Daily Beacon, Nov. 13
"Pro-Nuke Silent Majority Organizing" by Melanie J. Majors

Fusion Energy Foundation, the group known through their distinctive bumper stickers, "Feed Jane Fonda to the Whales, and Chappaquidick 1, Three Mile Island 0," brought their slogans, magazines and high powered pronuclear pitch to the area on a campaign stop at the Grants post office Wednesday. "Our goal is the production of 2,500 power plants in the next 25 years," said Joe Billington, a member of the FEF. "All over the country we are organizing the silent majority. . . . We are setting legislation and programs we want Congress to act on."

The Smithsonian, Dec. 1980
"An Earthly Furnace Fueled by Fusion Nears a Crucial Test" by Philip Boffey

. . . Enthusiasts almost always describe fusion as a potential dream source of energy—safe, clean, cheap and inexhaustible. . . . The Fusion Energy Foundation calls it "the gateway to a new world of abundance" in which there will be no technological obstacles to conquering poverty, hunger and disease.

Weekly Moultrie [Ga.] Observer, Dec. 18
"Food-People Conflict Hinges on Technology" by Dr. Broadus Brown, Ga. Agricultural Experiment Stations

[The Global 2000 Report] paints a rather grim picture about people and food and about the total well-being of the human race generally. . . .

It is reported in an article in *Fusion* . . . that the Global 2000 Report projections were based on the technology for food production in use in 1975. If that is the case it is no wonder the projections are so dismal. . . . In the same Nov. 1980 issue . . . is a whole section entitled Science versus Scarcity with the subtitle High Technology Agriculture Can Feed the World. It is a refreshing contrast to the reports from the gloom and doomers we have been seeing.

The Ann Arbor News, Jan. 16
"Nuclear Fusion 'Ready' for Development by Industry," UPI release by LeRoy Pope

The time has come to turn much of the fusion energy engineering program over to industry, says Leonard F. Reichle, an Ebasco Services vice-president. . . . He says in the February edition of *Fusion* magazine that the scientific program now is so far advanced that a Center for Fusion Engineering ought to be created to coordinate and expedite the ultimate development of commercial electric power by means of fusion.

Independent School, Quarterly of the National Association of Independent Schools (Boston), February
"The Wave of the Future?"

Sensing the American public's growing interest in science, both *Time* and *Newsweek* began publishing science magazines last year. To satisfy the curiosity of a younger readership, the Fusion Energy Foundation started to publish *The Young Scientist* in December. Designed for middle school students, the first issue of the magazine contained articles on space museums, NASA's solar polar exploratory mission, a fusion power experiment at Princeton, and an interview with scientist Steve Dean. . . . tour of the Alcator tokamak at the Massachusetts Institute of Technology. The group of 15 youngsters and 10 adults were taken on a VIP tour of the facility by Dr. Bruce Montgomery, a leader of the program.

Future tours are planned for Seabrook, N.H. and Connecticut nuclear plants, and the Foxborough Company, a manufacturer of instrumentation panels used in nuclear plants. Participation is open to young scientists of all ages.

Space Center Offers Fusion Bonus

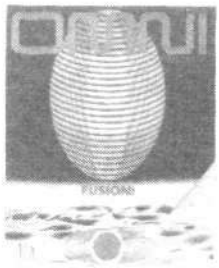
The Alabama Space and Rocket Center in Huntsville, Ala. is offering its members a special *Fusion* bonus: a one-year subscription to *Fusion* magazine ("fantastic coverage of the frontiers of science") for a reduced rate of $14 a year, or a combination subscription to *Fusion* and *The Young Scientist* for $20 instead of $28 a year.

For information about the space center's educational museum and "Explorer" membership program, write the Membership Office, Alabama Space and Rocket Center, Tranquility Base, Huntsville, Ala. 35807, or call (800) 633-7280.

FEF Testifies at Hearings

Marsha Freeman, FEF Washington Representative, testified before the Senate Committee on Agriculture Jan. 6 to support the confirmation of John Block for Secretary of Agriculture. The FEF testimony stressed the necessary scientific frontiers in agricultural research for the next decade.

Freeman also testified at the confirmation hearings of James Watt for Secretary of the Interior before the Senate Committee on Energy and Natural Resources Jan. 8. Two of the western states senators present at the hearings, Senators Wallop (R-Wy.) and Domenici (R-N.M.), were excited by the water development plan proposed in the FEF statement.



OMNI'S CONFUSION

The Jan. 1981 issue of *Omni* features fusion energy in a way that probably left many *Fusion* readers puzzled. Aside from a lead article that fairly and excitedly portrayed the promise of fusion for the 21st century, the overall effect of the *Omni* coverage was an attack on the leadership of the magnetic fusion energy program.

What the *Omni* coverage conveys is that the alternate proposals for fusion have gone unfunded because the national laboratories and their associated industrial contractors are working with the fusion officials in the DOE to fund the mainline tokamak program. At a time when the axe is poised over the fusion budget and, in fact, over the present leadership of the Office of Fusion Energy, the effect of *Omni* is to support the budget cutters and those who would dump the very leadership that has built the successful fusion program.

It is a tribute to the DOE Office of Fusion Energy as well as to the leaders of the national laboratories that the fusion program did not dissolve under pressure from former energy secretary James Schlesinger, who tried to pit one program against another in his budget cutting.

To guarantee the success of any particular approach, a broad-based fusion effort is essential. The various fusion experiments are not unrelated and, in fact, the tremendous success achieved over the past decade is primarily the result of the interaction of seemingly widely diverse experiments. The first thing is to demonstrate that we can achieve fusion with the most developed system. Alternate proposals, such as the one discussed in the *Omni* interview with Robert Bussard, are possible only when there is sufficient elbow room to fund a few selected high-risk efforts. It is, of course, desirable to have the kind of funding that will make this possible.

The fusion program will not meet the goal spelled out in the Magnetic Fusion Energy Engineering Act of 1980—a demonstration commercial reactor by the year 2000—unless the current program is fully funded at $525 million and its leadership is supported. *(For a review of some specific scientific questions raised in the* Omni *articles, see the Letters section.)*

* * *

IDENTIFYING POTENTIAL NUCLEAR SABOTEURS

The results of a recent psychological study performed by the London House Management Consultants of Park Ridge, Ill. suggest that it may be possible to prevent nuclear crime or sabotage from occurring in nuclear facilities by using appropriately designed employee screening tests.

After completing two series of tests using 45 and 74 anonymous subjects and examining various data correlations, the experimenters concluded that it is possible to identify those individuals most likely to commit acts of nuclear sabotage and, therefore, reject them during preemployment screening and clearance processes.

In a recent paper on the subject titled "Psychologically Profiling Endorsers of Nuclear Crime and Sabotage" by John Jones and Daniel Scruggs, the authors comment: "High endorsers of nuclear crime engaged in significantly more: (a) types of major crimes and (b) types of violent crimes during the past two years compared to low endorsers of nuclear crime. Thus subjects in the High Endorsement Group were reliably more likely to commit crimes in the workplace than subjects in the Low Endorsement Group. . . . These findings suggest that psychological tests such as the PSI [Personnel Selection Inventory] can be used to screen out job applicants who both endorse and have a high probability of committing employee crime and misconduct in nuclear facilities."

In another recent study Jones also stated, "High endorsers of nuclear crime (a) held more favorable attitudes/cognitions toward theft and illicit drug use and (b) they were more emotionally unstable and prone to lose impulse control and behave aggressively than low endorsers."

The authors go on to recommend further testing and development/research but believe eventually that these techniques can lead to a useful screening tool for nuclear utility companies.

* * *

SCIENCE EDITORIAL ATTACKS DEVELOPMENT

Science magazine departed Jan. 30 from a months-long series of editorials calling for industrial expansion, expanded science educaton, and, in general, for a U.S. scientific renaissance to run an attack on "the modern ethic of development." The editorial column that day was given over to Kingsley Davis from the Center for Advanced Study in the Behavioral Sciences, who starts with the headline "It Is People Who Use Energy" and goes on from there to prove that we can solve the energy crisis by eliminating people.

"It follows that stopping or reversing population growth could play a major role in solving the energy prob-

lem," Davis tells the readership of the magazine of the American Association for the Advancement of Science. We hope that *Science* readers notice that without people, there also would not be any advancement of science—and that they find out why it was felt that this zero-growth viewpoint deserved editorial space.

* * *

N.Y. TIMES ATTACK ON LIVERMORE TOPS KGB SLANDER

A Jan. 18 article on Lawrence Livermore National Laboratory in the *New York Times Magazine*, titled "New Life for Nuclear City," tops a KGB-authored slander called "Livermore, City of Death" that appeared several years ago in the Soviet *Literary Gazette*. The *Times* article, written by Stewart McBride of the *Christian Science Monitor*, purports to show that with defense-oriented Ronald Reagan in office "Livermore's controversial weapons designers will come back into the national spotlight again—to the satisfaction of those who believe the new Administration should and will 'carry a bigger nuclear stick'; and to the dismay of those who worry about the . . . hazards of radiation near development or testing sites." However, its main point is to support California Governor Brown and the environmentalist groups trying to shut the laboratory down because it has something to do with radiation.

Livermore, a major U.S. weapons development laboratory—no warheads are manufactured there—and one of the top international labs working on the development of magnetic and inertial fusion energy for electric power production, is responsible for keeping the United States at the forefront of scientific and technological research.

How does the *Times* article portray the most advanced fusion laser in the world? "Whether the Livermore laser, named Shiva, after the Hindu god of destruction, . . . is creating miniature stars or testing tiny H-bombs depends on one's perspective."

Poniatowski

Continued from page 16

Question: Isn't England also suffering from the monetarist economic policies of Milton Friedman and Friedrich von Hayek?

In monetary matters, I am very empiricist; I avoid having theories.

Question: But you have proposed the creation of a monetary system based on gold. . . .

Not based on gold alone. If you create a system based on gold, you will kill your international exchanges, because gold production will never follow the evolution of world exchanges. A strictly gold-based system would be an extremely dangerous thing.

Question: Then what system do you *envision*?

I think that we should have a system of reciprocal credits. That is to say, there comes a time when you have to pay your debts in gold. I think that the normal system of international exchanges requires large amounts of credits between the different federal and national banks.

However, beyond a certain deficit, which should be agreed upon internationally, the settlements should include a fraction of payments in gold, so that there is some discipline, some will to redress a situation if it becomes abnormal.

***Question:* As you know, there is a group of individuals around the new administration, including Jack Kemp, Art Laffer, and others, who are more or less "goldists." Do you think that the new administration will have a different position on gold from its predecessor?**

You are in a better position than I am to answer this question. But I do think there will be some thinking on this problem. What I think is that as much as a narrow, strict monetary policy based on gold is terribly dangerous, I also think that the other extreme of a system that is totally detached from gold is also dangerous, because it means general indiscipline: There are no sanctions, no limits built into the system.

With a system based only on gold, you run the risk of an international commercial and economic crisis, since such a system would reduce the volume of trade. However, if you have a currency that is completely detached from any discipline—gold is not significant as gold; it's the discipline of gold—then you fall into the opposite risk, the risk of inflation and related problems.

So I think we must look for a solution that has all the flexibility of an international monetary system based on exchanges and credit lines, with certain sanctions when a specified percentage of balance of payments deficit is reached.

Question: A question of interest for our American readers: What are the *possibilities for cooperation* between France and the United States under the new Reagan administration?

When you have a new partner, you have to get to know him. You must have contact that will permit you to get to know the man opposite you, what he wants, where he wants to go, how he wants to get there, and with whom.

Question: Do you have a special message for our American readers?

Yes. The problem of developing nuclear energy is a considerable one, because it means moving forward the frontiers of energy. We have reached a roadblock with the traditional oil- and coal-based energy systems, and nuclear energy will remove this roadblock.

However, it is not entirely in this way that I would characterize the civilization that we are entering, which is a scientific civilization. I think that this civilization will be characterized by computers and *télématique* [computer applications in the consumer sector]—that is to say, not by the multiplication of man's muscular power, which is characteristic of the machine and of the industrial cycle, but by the multiplication of man's capability for memory and his intelligence.

Making Antiscience Popular

Cosmos
Carl Sagan
13-part television series, Public Broadcasting Service, Carl Sagan Productions, Inc., 1980
New York: Random House, 1980, $19.95

Throughout the fall of 1980, U.S. television audiences were treated to the spectacularly popular PBS series *Cosmos*. Hosted by NASA consultant and astrophysicist Carl Sagan, the 13-part series promised to take its viewers on a "tour of the cosmos," providing an exciting popular science education along the way, with topics ranging from the history of science to modern theories about planets, stars, and galaxies.

Yet somehow, along the way, the fascinating predicates of science were turned into lists of facts, with the underlying lawfulness of the universe replaced by unknowable infinities of worlds within worlds. By ignoring the important questions of science, Sagan led his generally proscience audience, who agreed with him on the particular scientific facts, to conclude that Amerindian legends, Hindu mysticism, and environmentalist philosophy can tell us more about the universe than can science. Since man is merely a "mote upon the cosmic shore," he has much to learn from his "cousins, the oak tree and the intelligent blue whale," who have found their own ways to answer the cosmic riddle.

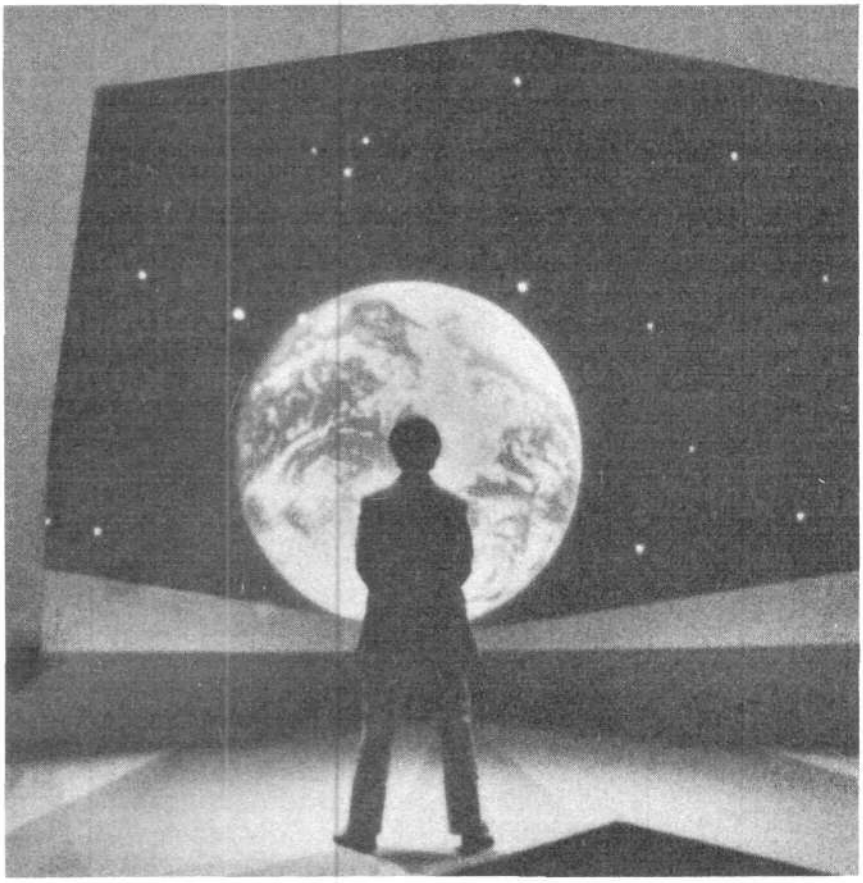
An examination of the content of the series will convince you that *Cosmos* is aimed at destroying comprehension of and trust in science and technology among the broadest possible layer of the U.S. population. In place of real science—which has always been an expression of mankind's moral commitment to human progress through mastery of the natural universe—*Cosmos* proposes an "Aquarian" version of science based on environmentalist irrationalism and a touchy-feely "consciousness."

The Cosmos series was funded through a grant to the Public Broadcasting Service of more than $1 million from the Atlantic Richfield Company (ARCO). The policymakers at ARCO, chairman Robert O. Anderson and president Thornton Bradshaw, are among the most prominent and influential American *opponents* of scientific, technological, and cultural progress, committed to the success of what insiders term the *Aquarian conspiracy*.

'Grassroots' Zero Growth

Anderson personally funded the first Earth Day in 1971 and gave $200,000 to create the Friends of the Earth organization as a "grassroots" opposition to technological progress. Both Anderson and Bradshaw are members of the zero-growth Club of Rome and the Aspen Institute for Humanistic Studies. Aspen prides itself on originally creating the antinuclear movement and devising the Malthusian "environmentalist" belief system, *that science and technology are in*trinsically evils inflicted by man on nature.

Where does the *Cosmos* philosophy miss the boat on real science? The essence of science is not existing scientific information, nor is it scientific artifacts such as pictures of Mars, telescopes, or test tubes. All existing scientific knowledge is subject to being superseded by new discoveries, and the artifacts are still more ephemeral. What is real, what is permanent and essential about science, is not specific discoveries, but the method by which discoveries are made and can continue to be made. This creative, scientific method was summarized in its most elaborated and explicit form in Plato's *Timaeus* as the "hypothesis of the higher hypothesis."



Sagan: Man is merely a "mote upon the cosmic shore."

The core of this method is the belief that the evolving laws of the universe are coherent with the human mind's own notion of lawfulness, so that the truth of the universe is fundamentally knowable to man. The universe, as Kepler correctly realized, is a continuing creation, the unfolding of a continuously efficient, continuously creative principle. As Kepler put it, "Geometry is one and eternal, a reflection out of the mind of God. That mankind shares in it is one reason to call man an image of God." The human mind, reflecting on the ordering principle of man's successive scientific-technological masteries of nature, is capable of understanding the plan ordering the heavens.

This is why Kepler's method of scientific hypothesis, of seeking the overall origins of the solar system and the global lawfulness involved to explain the orbits of particular bodies, is equally valid today in hypothesizing about the Voyager data on Saturn. Any Newtonian attempt to explain the Saturnian system comes up against the insoluble "three-body problem."

Sagan, however, dismisses Kepler's method as mysticism: the "Pythagorean idea of a perfect and mystical world . . . was an integral component of Kepler's early training," and claims that "All three of Kepler's laws of planetary motion can be derived from Newtonian principles. Kepler's laws were empirical, . . . Newton's laws were theoretical."

On the contrary, as any competent mathematical analysis demonstrates, Newton's "laws" were merely particular cases, frozen in time, of the evolving laws discovered by Kepler.

The Cosmos Method

In Cosmos, Sagan adopts a consistent form of distortion in order to focus audience attention away from the coherence of man's mind with the astrophysical phenomena being presented. For all man's science, he is but a speck of dust in the vastness of the cosmos, proclaims Sagan, while a psychedelic artist's conception of galaxies without end swirls by on the screen. Suddenly, we see Sagan sailing through space in a flying saucer, his hypnotic voice assuring us that somewhere out in this vastness there exists other life, superior civilizations who can solve all our problems.

Sagan's fascination with infinite collections of *things*—aided by the large scale of astrophysical phenomena and the use of psychedelic images—belies the deeper scientific fallacy that Sagan's nightmare embodies. Sagan is terrified of nature because he cannot grasp the self-ordering processes governing its development. What Sagan cannot understand, he asserts, must *have no explanation*—except perhaps if you accept extraterrestrial superbeings or Zen Buddhist ramblings as scientific hypotheses.

"Sagan presents genetics and evolution with a strict 'survival of the fittest' perspective, ignoring the evidence for global, macroscopic ordering principles. Everything from genes to the human mind is described in terms of computer bits."

Sagan is not the first "scientist" to suffer from this problem. Isaac Newton, who denied man's powers of mind in his famous refusal to "frame hypotheses," spent his life plagiarizing and banalizing the original work of Kepler and Leibniz, since he could not share in their method of creative discovery. Newton engaged in black-magic cult practices during the very period of his life he supposedly devoted to science. But then, according to Sagan, Kepler was also a superstitious fool outside his narrow area of scientific expertise—a view totally at odds with the abundant documentation of Kepler's training, writings, and method.

Just such hostility to a universe knowable by human reason runs through Sagan's discussions of modern astrophysics—particularly where the phenomena in question cannot be comprehended in Newtonian terms as collections of isolated *things.* In discussing questions like the space-time continuum or "black holes," Sagan's conclusion is that here science must leave off and black magic take over.

Wormholes and Sleeping Gods

For instance, Sagan presents a conventional account of British scholar Edwin Abbott's book *Flatland,* a two-dimensional world plane inhabitated by little triangles and squares, to whom our three-dimensional universe would be totally unknowable. He then says that the cosmos may be four-dimensional in nature, and we merely three-dimensional "flatlanders": "If a fourth-dimensional creature existed it could . . . appear and dematerialize at will, change shape remarkably, pluck us out of locked rooms and make us appear from nowhere. It could also turn us inside out!"

"We can imagine . . . wormholes [through black holes] as tubes running through the fourth physical dimension. We do not know that such wormholes exist. But if they do, must they always hook up with another place in our universe? Or is it possible that wormholes connect with other universes?"

"What would those other universes be like?" asks Sagan. "Would they be built on different laws of physics? . . . To enter them, we would somehow have to penetrate a fourth physical dimension. . . . Poised at the edge of forever, we would jump off. . . ." In other words, to explore other universes, try some LSD.

Or, if this does not work, there is always Hinduism:

"There is [also] the deep and appealing [Hindu] notion that the universe is but the dream of a god who . . . dissolved himself in a dreamless sleep. The universe dissolves with him until . . . he stirs . . . and begins again to dream the great cosmic dream."

"It is by no means clear that the cosmos will continue to expand forever. . . . The universe may hold together gravitationally and partake of a very Indian succession of cycles, expansion followed by contraction, universe upon universe, cosmos without end."

Rejecting the method of hypothe-

sis, Sagan presents the history of scientific development with the aim of obliterating the Platonic tradition: "In the suppression of facts, the sense that science should be kept for a small elite, the distaste for experiment, the embrace of mysticism, and the easy acceptance of slave societies, [Plato and Pythagoras] set back the human enterprise."

As for Kepler, Sagan actually goes so far as to assert that Kepler made his discoveries by rejecting the Platonic tradition in favor of the empiricism of Francis Bacon and Newton: "Kepler was shaken at being compelled to abandon his faith in the Divine Geometer. . . . The Earth, wracked by wars, pestilence, famine and unhappiness, fell short of perfection. . . . If the planets were imperfect, why not their orbits as well? He tried various ovallike curves, calculated away, . . . and months later in some desperation tried the formula for an ellipse."

Thus Sagan stands Kepler on his head. In the same vein he dismisses

"In Cosmos, Sagan adopts a consistent form of distortion in order to focus audience attention away from the coherence of man's mind with the astrophysical phenomena being presented."

Archimedes, ibn Sina, Nicholas of Cusa, Leibniz, Gauss, and Bernhard Riemann—that is, every Platonist whose scientific contribution laid the groundwork for modern civilization.

In like manner, Sagan presents genetics and evolution with a strict "survival of the fittest" perspective, ignoring the evidence for global, macroscopic ordering principles. Everything from genes to the human mind is described in terms of computer bits. And in his discussions of the future of our "speck in the cosmos," he predicts a fate similar to that of Venus, the "incarnation of hell," unless we curb our technology: "Earth is a tiny and fragile world. It needs to be cherished."

Sagan is no stranger to the Aquarian conspiracy. He was on Carter's President's Commission for an Agenda for the 1980s, whose first report was the leading factional document in favor of dismantling heavy industry and depopulating America's leading urban centers. A deeper look at the membership of his Planetary Society shows an overlapping of names with those of the Aquarian conspiracy and environmentalist movement.

Planetary Antiscience

Supposedly committed to an aggressive national space program, the Planetary Society has drawn in many serious advocates of high-technology space exploration. But the society's program is actually along the lines of Sagan's statement, "The cost of major ventures into space . . . is so large that they will not, I think, be mustered in the very near future. . . . Even then there are probably more pressing needs here on Earth."

In place of fusion-powered rockets for interplanetary travel, the society calls for the development of a "solar sail"; in place of manned expeditions to the planets and asteroids to set up colonies and mine their wealth, the society calls for robot probes to explore the solar system, at present levels of technology; in place of an aggressive R&D program to improve man's ability to master the solar system, the society calls for a vast radiotelescope search for extraterrestrial intelligence, undermining man's faith in his ability to control his destiny.

Sagan goes so far as to object to radio because "uncontrolled growth of terrestrial radio technology may prevent us from ready communication with intelligent beings in distant worlds." But then, he also objects to steamboats because their propeller noise pollution has destroyed the global transoceanic communication grid used by "intelligent" whales!

It's a sad reflection on our society that parents wishing their children to acquire a scientific education must let them be subjected to Sagan's brand of "antiscience" science.

—Robert Zubrin

"The environmentalist-terrorist groups are merely infantry divisions deployed by some of the most powerful political forces in the United States."

—Robert Greenberg
Editor, Investigative Leads

Over the last decade, the United States and other industrialized countries have been under all-out attack by the forces of the so-called environmentalist movement. Radicalized youth, "social-activist" lawyers of the Ralph Nader variety, and "expert studies" have all been combined to convince many that growth and prosperity are things of the past.

Now, *Executive Intelligence Review* is making available a comprehensive study on the environmentalist movement, showing how the movement is controlled from top to bottom by some of the most prestigious power centers in the United States: New York-based foundations and law firms, and federal agencies, under the umbrella of the Council on Foreign Relations.

Who Controls Environmentalism?

A special report prepared by *Investigative Leads*, a research arm of *Executive Intelligence Review*.
Available December 1, 1980. **$50.**

For ongoing domestic and international intelligence, subscribe to the 64-page weekly journal, the *EIR*. For ongoing intelligence on the environmentalist movement, subscribe to *EIR's* bi-weekly newsletter, *Investigative Leads*.

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Edwards

Continued from page 24

president, Congress, and the nation, to assure reliable supplies of reasonably priced energy. . . . Our economy, the productive machine, which makes our way of life possible through meaningful jobs, is dependent on energy. We must manage the system effectively now, and plan wisely for the future."

The Dialogue

What about the "free market" in energy R&D?

Senator Dale Bumpers questioned Edwards as follows:

Bumpers: In your statement, you stated that we needed to develop our own energy resources and that it ought to be done by the private sector. And in the *Columbia Record* on Feb. 3, 1976, you said that we favored subsidies for the nuclear industry. Which is it?

Edwards: Senator, it depends on what you call subsidies, really. If we hadn't subsidized nuclear energy for defense and the nuclear energy program, which originated in the defense of America, we would probably all be in Siberia now rather than in the free world.

Bumpers: Isn't that effective subsidy of industry? For example, we are spending roughly $400 million a year on fusion research right now. And in my opinion, by the year 2000, we will probably spend close to $10, $20 billion in today's dollars; and yet when that becomes a perfected technology, industry will get the benefit of it as they have all the money we have spent on nuclear research. Is that not the same thing as a subsidy?

Edwards: Senator, in a way it is, yes.

Bumpers: You have no quarrel with that?

Edwards: No quarrel with that.

Bumpers: Under the $4 billion in the 1981 budget for R&D [in the DOE] you don't have any quarrel with that?

Edwards: I don't know whether we can spend that much efficiently, Senator, . . . but I have no quarrel with spending money for that development.

A Holding Pattern

In his opening statement as the chairman of the Senate Energy Committee, Jim McClure, a Republican from Idaho, reviewed the dismal past four years of Carter energy policy. He then said he was confident that in working with the new Republican leadership in the Senate, Edwards would be successful in turning the situation around.

"During the past four years, the Carter administration has placed this nation's nuclear industry in a virtual holding pattern. We must now resume our development of nuclear energy as a major component of our domestic energy supply. That can be accomplished if the new administration takes initiatives in a number of areas . . . in the area of nuclear waste policy . . . spent fuel storage . . . removal of the current impediments to international nuclear commerce, and improved procedures for the siting of nuclear power plants and waste facilities. . . . I fully expect that the new Secretary of Energy will be at the center of these initiatives."

Many senators expressed their concern that the secretary himself, not the OMB, Treasury Department, or Secretary of State Alexander Haig, be responsible for formulating energy policy for the administration, and Edwards pledged he would take that responsibility.

Edwards can expect support from McClure and majority committee member Pete Domenici, a New Mexico Republican, who is also the new chairman of the important Senate Budget Committee.

On Edwards's Qualifications

At the Senate confirmation hearings for Energy Secretary Jim Edwards Jan. 12, the charge was made that Edwards did not come out of the energy industry and therefore might lack necessary experience. To that charge Senator Malcolm Wallop (R-Wy.) remarked: "It would be unlikely in the present climate of Washington that we would ever get somebody to be the nominee for secretary of energy if he came from the energy world," so ready would critics be to charge the nominee with representing "special interests."

Dr. James Burrows Edwards has, in fact, had extensive experience in the field of energy, in public policymaking, and in management.

Before becoming the first Republican governor of South Carolina in more than 100 years in 1975, Edwards was a state senator, while he carried on private practice as an oral surgeon. In the state senate, Edwards was a member of the nuclear energy committee, and later, after becoming governor, he chaired the new nuclear energy subcommittee of the Committee for Natural Resources and Environmental Management of the National Governors Association.

Governor Edwards also served as chairman of the Southern Governors Conference and directed its activities through the Southern States Energy Board.

Edwards stated at his confirmation hearings that he would have "no intellectual difficulty" in consulting experts in the scientific and energy fields to help him formulate DOE policy. With this attitude, competent advice, Senate and House backup, and executive support, the new secretary can play an important role in restoring energy growth and the economic health of the country.

FEF Testifies For Fusion

Testifying at the confirmation hearings for the new energy secretary, Fusion Energy Foundation executive director Dr. Morris Levitt stressed that it is only "the most rapid possible application of inventions and breakthroughs in technology and science that can provide us with the optimal economic/strategic mix of energy resources."

Levitt, one of the five public witnesses given the opportunity to testify, expressed the FEF's concern that such scientific criteria were not being employed. According to reports from the scientific community, Levitt said, the OMB transition team had recommended that approximately $50 million could be cut from the DOE's fiscal year 1982 request for the magnetic fusion program. If this were done, Levitt pointed out, we would repeat the blunders of the Carter administration, which chopped $60 million from the Ford administration's fusion budget request.

These cuts led to a cutback in vital programs in fusion from which the program has still yet to recover, Levitt stressed. Supporting the Edwards nomination, Levitt said that he hoped the policy issues he raised would be given close attention by both Edwards and the Senate Energy Committee.

Testifying along similar lines, Susan Kokinda of the National Democratic Policy Committee stressed that the federal government has a crucial role to play in the area of advanced research and development. "Overzealous budget-balancing mentality, applied to the wrong areas of R&D," she said, could be devastating to the possibilities of actual economic recovery."

Kokinda explained that "Economic growth will be restored and inflation brought under control, not merely by cutting taxes and certainly not by an indiscriminate meat-axe approach to the budget, but by the 'shock-wave' effect of introducing new technologies into the economy. . . . The key program in that respect . . . is the implementation of the Magnetic Fusion Energy Engineering Act of 1980."

Disturbed by reports of possible cuts in the magnetic fusion program, Senator Domenici, chairing the hearings for Senator McClure, replied to Kokinda: "I think your observation of a meat-axe [approach to budget cuts] as inappropriate or an across-the-board percentage [cut] is indeed applicable, principally in the energy field. From this senator's standpoint it is totally inappropriate. It must be selective and I certainly agree that if we are going to be successful, we cannot refuse to fund those technologies that have promise, and that are in the future. We cannot solely rely on a very short-term kind of R&D or expenditures of money on short-term projects."

Congressional Line-up

New Prospects for High Technology

The presence of the new Republican majority in the Senate and the selection of new subcommittee chairmen in key committees of the House should change the prospects for advanced nuclear, breeder, and fusion authorizations in the 97th Congress.

The most important new assignments include:

Senator James McClure (R-Idaho)—chairman, Senate Committee on Energy and Natural Resources.

Senator Pete Domenici (R-N.M.)—chairman, Budget Committee, and chairman, Subcommittee on Research and Development of the Senate Energy Committee.

As leading members of the Senate Energy Committee in the last Congress, both McClure and Domenici were proponents of high technology and nuclear development.

Senator Mark Hatfield (R-Ore.)—chairman of the Senate Committee on Appropriations.

As ranking Republican on the Energy Committee in the last Congress, Hatfield supported fusion development but not nuclear energy.

Representative Marilyn Bouquard (D-Tenn.)—chairman of the Subcommittee for Energy Research and Production of the House Committee on Science and Technology.

Rep. Bouquard has been an outspoken supporter of both the breeder and fusion; she assumes the chairmanship of the subcommittee formerly chaired by Congressman Mike McCormack.

The chairman of the full House Committee on Science and Technology remains **Don Fuqua** (D-Fla.). He also now heads the Subcommittee on Energy Development and Applications. The Space Science and Applications Subcommittee, formerly headed by Fuqua, is now chaired by **Rep. Ronnie Flippo** (D-Ala.).

Representative Tom Bevill (D-Ala.) remains chairman of the Subcommittee for Energy and Water of the House Appropriations Committee.

McClure (left) and Domenici: both pronuclear and profusion.

Carter Bans Many Chemical Exports

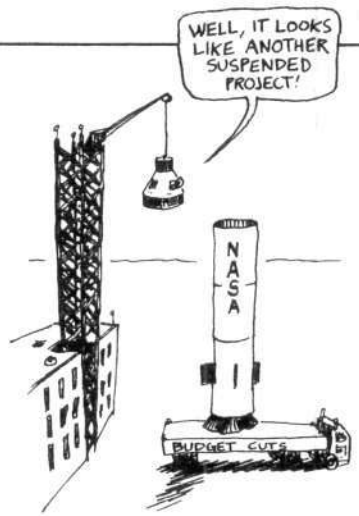
A last-minute executive order signed by former President Jimmy Carter Jan. 15, "On Federal Policy Regarding the Export of Banned or Significantly Restricted Substances," was the Carter administration's most far-reaching attack on the chemical industry and chemical use.

The order calls on the U.S. State Department to notify recipient countries of restrictions or bans that have been placed on chemical products they import from the United States; it requires that these proscriptions be published annually with all U.S. agencies; it instructs U.S. agencies to encourage international cooperation on all aspects of the environmental considerations; and, lastly, the order gives a government task force the authority to ban "a very small number of especially hazardous substances."

The executive order took the chemical industry by surprise, because the administration had promised up until the last minute that Carter would not sign the order and because the final version of the order is more damaging to the industry than the original version.

The order will have a potentially devastating impact on Third World countries, in advertising that the government is importing chemicals considered dangerous by some, even though the chemical—DDT or 2,4,5-T, for example—might be necessary for the population's well-being. Furthermore, the order adds to the momentum for an international environmental policing agency—an international Environmental Protection Agency—that will stand in the way of Third World development.

The order sets another dangerous precedent in placing trade policy in the hands of the State Department, where it can be used as a foreign policy tool. And it will discourage the development of new chemicals by the industry, because they might one day be declared "hazardous" and banned from the market.



NASA Budget Under the Axe

Outgoing NASA administrator Dr. Robert Frosch released the Carter administration's fiscal year 1982 budget request for the space agency to the press in mid-January, calling for a 21 percent increase over the previous year's budget. Taking into account inflation, the budget request of $6.7 billion is an approximate 10 percent real raise in the agency's spending capability.

"This is a good budget which moves us forward toward a new era of space transportation with the space shuttle and provides for continued progress in the areas of aeronautics, space science and the practical applications of space technology to problems on Earth," Frosch said.

However, he warned that the budget is "not as good as it should be if we are to revitalize NASA as the cutting edge of our scientific and technological progress."

Now, NASA sources report, the Office of Management and Budget of the new Reagan administration has proposed to cut $629 million out of the budget request—a 9 percent cut.

The OMB recommends that the cuts come primarily in the space science programs, including cancellation of the Galileo mission to Jupiter and the Venus Orbiting Imaging Radar mission, in addition to a delay of the fourth orbiter vehicle for the Space Shuttle. When the shuttle program was authorized in 1972, it was supposed to have five reusable vehicles for space transportation.

Scientists at the Jet Propulsion Laboratory in California are most concerned about the possible cuts. JPL manages all of NASA's planetary programs and with the cutbacks and delays of the past four years, JPL has already been forced to take on Department of Energy work that is not related to space to keep from laying off scientists.

Senator Harrison Schmitt (R-N.M.), an outspoken advocate of the space effort, will hold a special Washington briefing Feb. 23 to state his views on the NASA programs.

Global 2000

Continued from page 18

the government in turn maps onto an outside operation composed of some very powerful former administration officials. A few months ago, the Committee for the Year 2000 was formed, whose specific goal is to implement the *Global 2000 Report*. The key individuals involved in the group are Russell Train; Robert O. Anderson, chairman of the board of ARCO and head of the environmentalist Aspen Institute; former ambassador Elliot Richardson; and former secretary of state Cyrus Vance, who according to close associates "seeks to create a world order based on environmentalism." This group, consisting of Trilateral Commission members, is augmented by former secretary of state Muskie, one of the founders of the Earth Day celebrations.

Below this elite corps of environmentalists is the Citizens Committee for Global 2000, the Audubon Society, and other environmentalist sectlets. These groups are turning their attention from protecting endangered animal populations to reducing the human population.

This article was written by Lydia Schulman and researched by L. Wolfe of the Executive Intelligence Review.

Letters

Continued from page 8

the secretary of agriculture, has the authority even to propose areas for wilderness designation." And he goes on to cite Jack Brettler's contention that the Wilderness Act of 1964 was not supposed to go into effect until 1984. Mr. Engdahl, and perhaps Mr. Brettler, should reread these laws.

Section 4 of the Eastern Wilderness Act designates several areas, including "certain lands on the Pisgah National Forest, North Carolina," for wilderness study, to determine their suitability or nonsuitability for wilderness, and directs that the secretary of agriculture report his findings to the President who is to recommend to the Congress whether these areas should be designated for wilderness or nonwilderness use. That's directly opposite from Mr. Engdahl's contention.

Douglas R. Leisz
Associate Chief
USDA Forest Service
Washington, D.C.

The Editor Replies

The case of the Southern Appalachian Multiple Use Council *et al.* v. Bergland, Secretary of Agriculture, went to trial in Asheville, N.C. in January. Initiated by geologist Jack B. Brettler and joined by representatives of the forest products industry, the American and North Carolina Farm Bureau, and conservationist groups, the suit is the major challenge in the courts to the Roadless Area Review Evaluation (RARE II) initiated by former Agriculture Secretary Bergland, under which millions of acres of potentially mineral-rich land have been locked up pending possible wilderness designation.

At the trial Hamilton C. Horton, Jr., principal attorney for the Multiple Use Council, argued for a mandatory injunction to stop the illegal government lockup, declaring that Congress had explicitly reserved to itself the authority to designate what should or should not become wilderness under the Eastern Wilderness Act of 1975.

The act in fact reads: "Congress may, upon recommendation of the Secretary of Agriculture or otherwise, designate as study areas national forest lands east of the 100th meridian . . . for review as to suitability or nonsuitability for preservation. . . ."

Congress clearly intended just that. It was concerned about bureaucrats withdrawing national forest lands from harvesting, grazing, and other uses, and didn't want protracted "wilderness studies" to be a subterfuge to take forest lands out of production.

The outcome of the North Carolina trial will be an important indication of whether environmentalist barriers can be reversed through the courts.

William Engdahl
Contributing Editor

U.S. Steel on EPA

'We Are Not Disheartened'

Upon reading about an in-house memorandum of the Environmental Protection Agency advocating the gradual phase-out of the American steel industry, Fusion *reader George Stafford brought the matter to the attention of U.S. Steel chairman David Roderick. Here is Mr. Stafford's letter and excerpts from Mr. Roderick's response.*

Dear Sir:

Having a wife who has owned U.S. Steel stock for many years and being a patriotic citizen, I was shocked upon reading an article in the Jan. 1981 issue of *Fusion* magazine titled "Secret EPA Memo Plans End to U.S. Steel Industry."

There is no question but that you are well aware of the EPA's strangling regulations, but were you aware of this plan to destroy our most basic industry?

George F. Stafford
St. Petersburg, Fla.

Dear Mr. Stafford:

Thank you for your letter. . . . The thrust of the memorandum to which you refer is to deny the need for regulatory relief which we consider to be an important measure the government must implement in order for the steel industry to surmount our present difficulties and emerge strong and competitive. . . .

We are not disheartened by the sentiments expressed in the memorandum cited in the *Fusion* article. We see some promise in the fact that those who will be responsible for setting public policy in the coming years have shown an awareness of the need to reevaluate government regulatory programs. Hopefully, with the support and encouragement of interested citizens like you, government policies will be developed to enhance rather than impede the steel industry's revitalization. . . .

David Roderick
U.S. Steel Corporation
Pittsburgh, Pa.

The Space Shuttle

To the Editor:

I would really like to thank you for your cover story in the January issue about the space program. Very few people are aware of the huge economic benefits we received from it.

As the Space Shuttle nears its first launch into orbit, people need to know how this program can greatly help us in the future. Please keep up the good work.

Ted Apelt
Miami, Fla.

The Editor Replies

The latest results on the progress of the Space Shuttle will be covered in an upcoming issue. A timely letter to President Reagan to express your support for an expanded NASA space program might be in order, since proposals to slash the NASA budget are being considered now.

In Appreciation

To the Editor:

Fusion is a fantastic magazine. We have a son who is on . . . a fast attack nuclear submarine. He read *Fusion* while home on leave and found it quite interesting. It also relieved some of my feelings about nuclear exposure.

Barbara Vernon
Vallejo, Calif.

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Coming in the next issue

Thermonuclear Ignition by Means of Compact Devices
B. Coppi, R. Pozzoli, E. Sindoni, and A. Taroni

Magnetic confinement fusion in small, economically feasible devices is investigated.

The Beginnings of a Deterministic Theory of Turbulence
S. Bardwell

The amazing results of experiments and examination of the Voyager data on Jupiter imply that coherent structures are the rule, not the exception.

The IJFE, the theoretical publication of the Fusion Energy Foundation, will expand to a larger, semiannual journal in 1981. Subscriptions are $50 per volume. For more information, contact Dr. John Schoonover, Fusion Energy Foundation, Suite 2404, 888 Seventh Avenue, New York, N.Y. 10019. (212) 265-3749.

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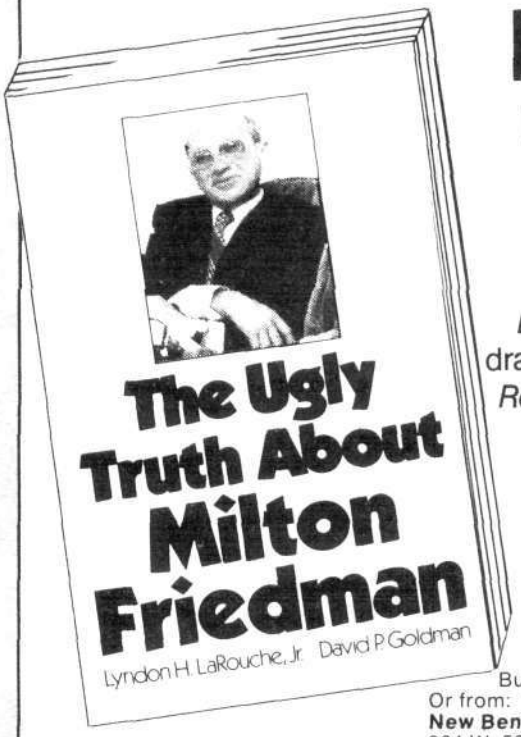

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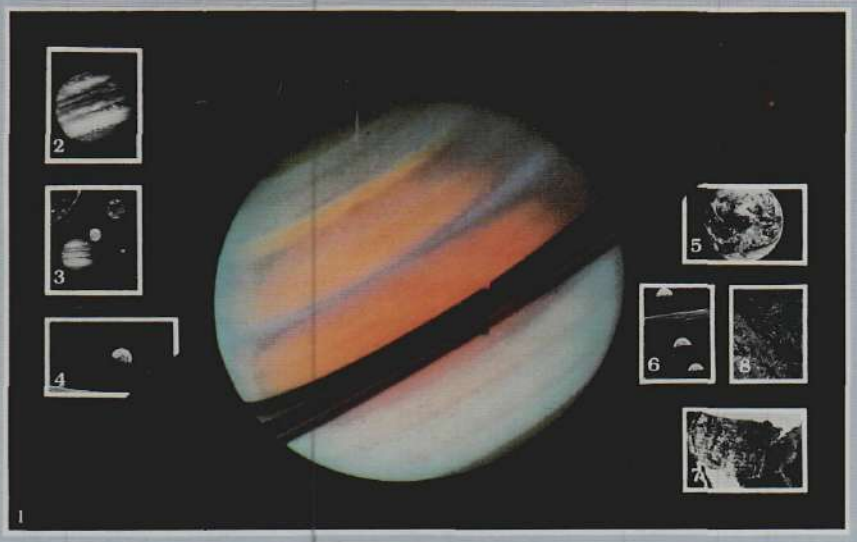

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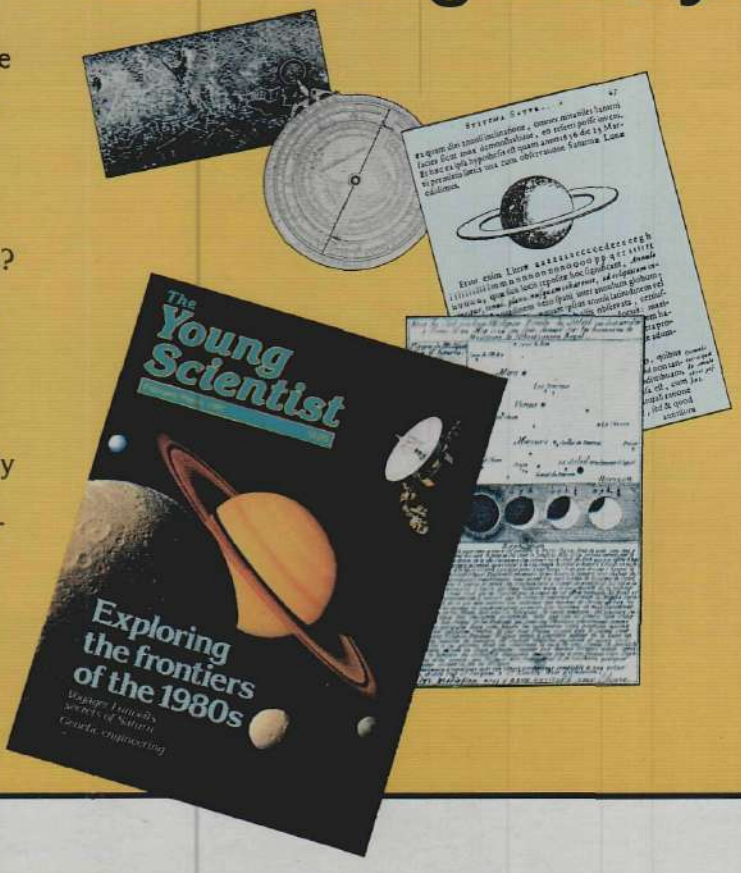

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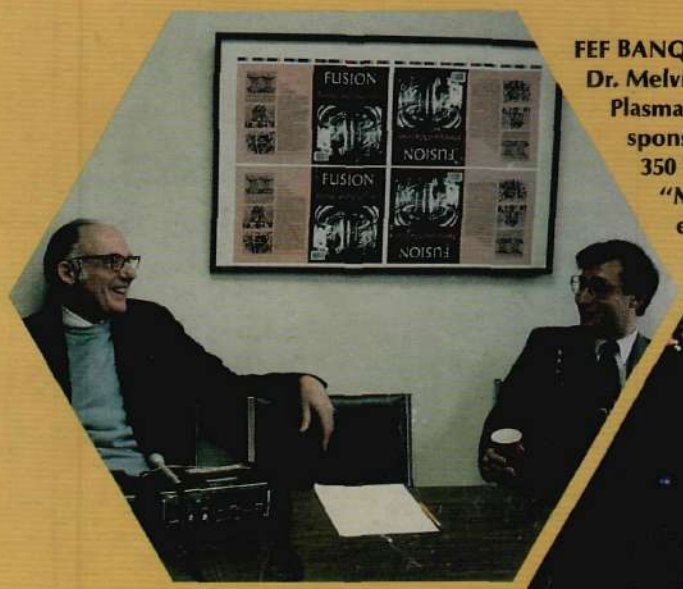

FEF BANQUET HONORS DR. GOTTLIEB

Dr. Melvin Gottlieb, who recently retired as director of the Princeton Plasma Physics Laboratory, was the guest of honor at a banquet sponsored by the FEF Feb. 6 at New York's Hotel Biltmore, where 350 fusion supporters paid tribute to his 25-year fusion career. "Mel is an authentic American hero," said Dr. Morris Levitt, executive director of the FEF. The program included three generations of fusion scientists.

SOLVING THE SATURN PUZZLE

The spectacular views of the Saturnian system brought to us by Voyager 1 are not an unsolvable puzzle, as many have claimed. Although the new data challenge the basic concepts of Newtonian physics, Dr. John Schoonover shows how seemingly inexplicable phenomena not only can be explained, but also can teach us much about the evolution of the universe.

BEHIND THE DECLINE IN U.S. EDUCATION

The facts and figures of the decline in U.S. education are plain enough to most Americans. Not so well recognized is the role of leading educator Jean Piaget in causing the downslide. Mary Gilbertson assesses the damage wrought by Piaget's theories and Dr. Steven Bardwell examines how the New Math is neither new nor mathematics.

The Cover. Above: Dr. Gottlieb addressing the banquet audience and Gottlieb and Levitt at a press conference at FEF headquarters, Carlos de Hoyos; Voyager's view of Saturn and its rings at 3.3 million miles, NASA; Jean Piaget from an illustration by Etienne Delessert in a book written by Piaget for young children, *How the Mouse Was Hit on the Head by a Stone and So Discovered the World,* © 1971 by Etienne Delessert, published by Doubleday & Company, Inc. Front cover: Photographs of children learning about science by Virginia Baier, Carlos de Hoyos, Philip Ulanowsky, Carlos Wesley, and USDA. Cover design by Christopher Sloan.