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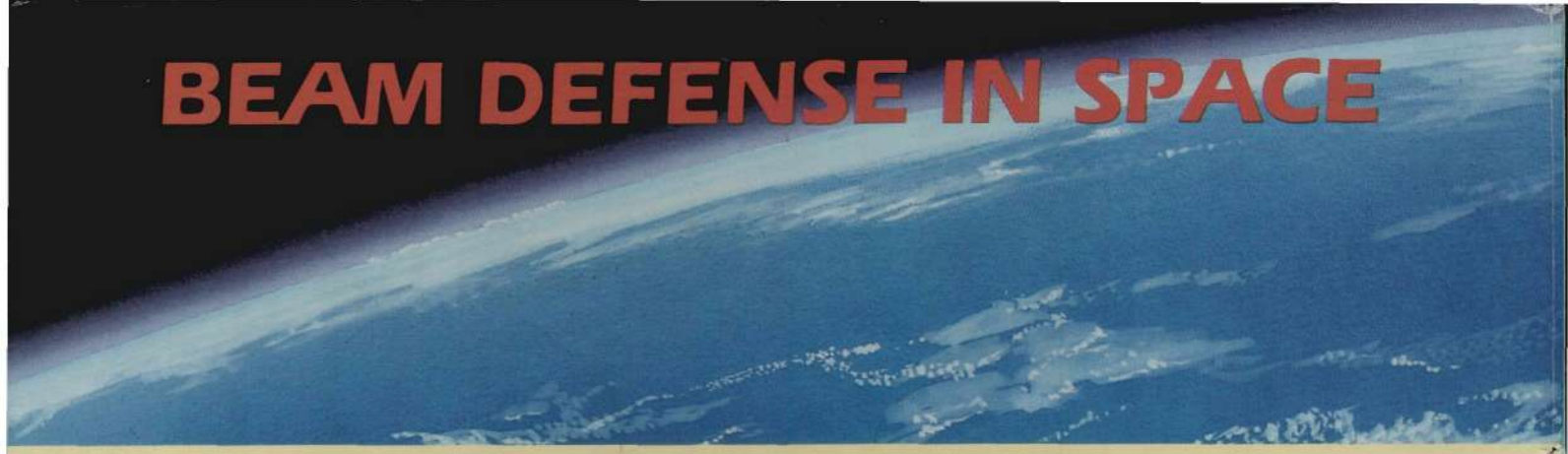

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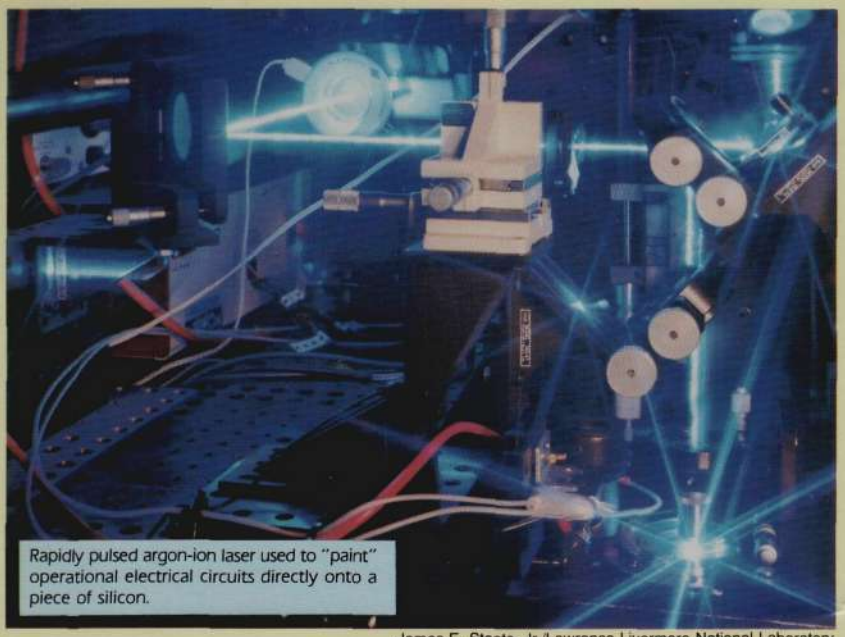

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Features

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On the cover: An argon laser, carried by a fiberoptic to operate deep within the human ear. The laser can vaporize tumors that occur between the inner ear and brain or drill into the inner ear to alleviate hearing impairment. Inset is an argon beam, 300 microns, passing through a human eardrum. Photograph by Alexander Tsiaras/ Science Source, Photo Researchers.

Stop the KGB Witch-hunt Against American Science

For two years the American scientific community has been subjected to an outrageous series of propaganda attacks aimed at social and legal ostracism of German-American scientists, including some of the very best scientists of NASA. The particular targets of this campaign of "old Nazi" calumnies have been the aerospace engineers and scientists of greatest stature in America's space effort, as in the case of Arthur Rudolph.

Rudolph came to the United States shortly after World War II. During the war he had worked at Peenemünde, the center for German rocket development, under the direction of Wernher von Braun. From 1962 to 1969, he was the project director for the Saturn V rocket, which took American astronauts to the Moon. In 1968, NASA awarded Rudolph the Exceptional Service Medal.

Last year, when the ugly charge was raised in the national press that he had personally abused slave laborers at the Nordhausen V-2 factory, Rudolph, now in his late 70s, chose not to spend his last years and life's savings mounting a legal fight against his accusers; instead, he quietly left the United States for West Germany.

Soviet Disinformation Against the SDI

The coordinating centers for this campaign against German-American scientists and against American science in general are the U.S. Justice Department Office of Special Investigations (OSI) and the Anti-Defamation League (ADL) of the B'nai B'rith organization. The sources, however, are directly East German and Soviet, and it is the KGB and the Stasi, the East German state secret intelligence service, that are picking out the targets. The not-so-subtle Soviet message is that President Reagan's SDI is based on German "Nazi" science, and to prove it, look at the "old Nazis" in the U.S. space and defense program. The so-called evidence the OSI produced against Rudolph, for example, consists of two witnesses manufactured by the Stasi, whose "testimony" is brandished by the OSI although the witnesses have denied ever making the statements used. The OSI has illegally refused to release its evidence to the West German government.

Now this same anti-SDI Soviet disinformation operation has attacked another German-American scientist, the late Krafft A. Ehricke, a brilliant rocket scientist and space pioneer, who designed the Centaur rocket and developed a comprehensive plan for settling and industrializing the Moon. A little-known newspaper, *Martyrdom and Resistance*, whose listed address and phone number are those of the Anti-Defamation League headquarters in New York City, alleged in an obituary of Dr. Ehricke, the "Nazi background of Dr. Ehricke and his wife." In the Jan.-Feb. 1985 issue, *Martyrdom and Resistance* made the further outrageous claim that "death spared them [the Ehrickes] an impending revelation of their past" by so-called Nazi hunter Charles R. Allen, Jr. No such "revelation" will appear from Allen, because it could never be substantiated. In fact, Allen and the Soviet agencies behind him would not have dared to make such a charge were Ehricke still alive to fight their lies. Interestingly, the only so-called evidence cited in this calumny is Allen's claim that Ehricke's "ideology has changed little. . . . He has been a contributor to *Fusion* magazine of Lyndon LaRouche."

This particular slander is standard Soviet propaganda against this magazine and against Fusion Energy Foundation board member Lyndon H. LaRouche, Jr. Since President Reagan's March 23, 1983 speech initiating the beam defense program, Soviet news outlets, including TASS, *Izvestia*, *New Times*, and East Germany's *Neues Deutschland*, have specifically attacked the FEF for supporting beam

Marsha Freeman

Renowned space scientist Krafft Ehricke (right) at the October 1984 NASA-sponsored conference on colonizing the Moon, held at the National Academy of Sciences in Washington. With him are his wife, Ingeborg Ehricke, and Phil Culbertson, the head of NASA's space station program.

defense and LaRouche for "inventing" Reagan's new doctrine.

Krafft A. Ehricke was one of the most creative and optimistic of the great space engineers and rocket pioneers of the 20th century, a man totally dedicated to human progress and dignity. To raise this crazy charge after his death betrays the Soviet and East German intelligence services' complete disregard for the truth. It betrays a Soviet KGB campaign, simultaneous in the United States and West Germany, of disinformation attacks against all potential collaborators of President Reagan's call to "make nuclear missiles impotent and obsolete"—the Strategic Defense Initiative.

Allen's Soviet links are known. Described by KGB journalist Oleg Polyanskii as his "closest Western contact," Allen is a professional collaborator of the East German Stasi and the KGB. His friend Polyanskii is a former New York bureau chief of the KGB and a specialist employed by TASS to accuse Western scientists of being Nazis. Allen is also the primary U.S. collaborator of the "European anti-Nazi" network known as the VVN, which is a controlled creation of the Stasi.

OSI: National Security Threat

The fact that a nominal agency of the U.S. government's Justice Department, the Office of Special Investigations, is acting as a channel for Soviet KGB and East German Stasi charges against German-American scientists is a threat to the national security of the United States. It is also a threat to the scientific potential—the hope of technological progress—of Western civilization as a whole, and of the nonaligned nations of the developing sector.

More than 500 German-American scientists in the United States alone are the targets of this agency and its so-called journalistic outlets, which include reporters at the *Bulletin of Atomic Scientists*, the *New York Times*, and the *Washington Post*. The Fusion Energy Foundation and LaRouche are its special targets. Ehricke was hounded shortly before his death by one Dennis King, a stringer for the Anti-Defamation League, *High Times*, and the *New Republic*, who specializes in slandering LaRouche. While preparing an article attacking FEF and LaRouche in summer 1984, King demanded of Ehricke on the telephone, "Is Arthur Rudolph also a member of the Fusion Energy Foundation?" And when another German-American scientist called the OSI to counter their lies about Rudolph, he was told that the agency wouldn't listen to him, because he was associated with the FEF and LaRouche.

Where does the OSI stand on the threat of Nazism today? The answer is clear. The OSI has refused to act on documented evidence of the pro-Nazi activities of the West German Green Party, whose leaders have given open speeches calling for the revival of "brother Hitler," and the OSI has used the East German-supported Green Party as a source against German-American scientists. We are only concerned with "old" Nazis, an OSI spokesman said, when questioned on whether the OSI was investigating Green Party activities, in particular those of party leader Petra Kelly, in the United States.

We call on the scientific and engineering membership organizations of the United States to publicly condemn the activities of the Office of Special Investigations and its associated journalistic outlets as a national security threat and a threat to the freedom of scientific work and association. The OSI itself and its admitted and primary dependence on Soviet and East German sources for its investigations should be investigated by Congress and dismantled.

Philip Ulanowsky

FEF's Gallagher: The cuts in the fusion budget will hurt the beam defense program.

News Briefs

FEF EXECUTIVE DIRECTOR TESTIFIES ON FUSION BUDGET

Fusion Energy Foundation executive director Paul Gallagher presented the FEF's views of the U.S. magnetic fusion budget before the House Committee on Appropriations April 3. Gallagher told the congressmen that the "deep cuts" recommended in this "crucial research program" will have a serious impact on the Strategic Defense Initiative, future energy supplies, and the overall economic health of the nation.

INDIAN MINISTER BACKS KRA CANAL PROJECT

Indian Minister of State for Planning, K.R. Narayanan, inaugurated *Fusion Asia*'s two-day conference in New Delhi April 12, and lent his support to the proposal for a new canal through the Kra Isthmus of Thailand and a "Great Projects" approach to industrializing India. The conference, titled "India, An Agro-Industrial Superpower by the 21st Century: A Strategy for Economic Breakout," was attended by 60 participants representing the leading industrial sectors of the country.

"Though extravagant, because we in India do not normally talk of superpower status for us, the title for this conference is an encouraging theme, an optimistic theme, and maybe a realizable thing," Narayanan said. "To give even a little to the people, we cannot do it with small science, with small technology, but only by mastering high technology and the most advanced technology."

WEINBERGER CHALLENGES MEDIA ATTACKS ON BEAM DEFENSE PROGRAM

Defense Secretary Caspar Weinberger began his speech to the American Society of Newspaper Editors in Washington April 11 with an attack on the *New York Times* and other media for their continuing editorial refrain that the Strategic Defense Initiative is "technologically impossible." "To them I would quote a *New York Times* editorial, Dec. 10, 1903: 'We hope that Professor Samuel P. Langley will not put his substantial greatness as a scientist in further peril by continuing to waste his time, and the money involved, in further airship experiments. He is capable of services to humanity incomparably greater than can be expected to result from trying to fly.' "

"Samuel Pierpont Langley was the foremost American scientist of the day," Weinberger continued. "One week after that editorial appeared in the *New York Times*, two bicycle shop owners named Orville and Wilbur, who had a dream, took off from Kitty Hawk. Fortunately, they didn't believe everything they read."


Stuart Lewis

Weinberger: The New York Times *said the airplane wouldn't fly.*

WASHINGTON POST INTERVENES TO STOP FEF BEAM DEFENSE BRIEFING

The *Washington Post* intervened to try and stop a March 18 congressional briefing in Washington, D.C., sponsored by the Fusion Energy Foundation on the topic of the Strategic Defense Initiative, the economy, and Soviet strategy. Shortly after invitations to the briefing were sent out, the *Post* reported March 13 that Indiana Senator Richard Lugar, whose office had arranged a conference room for the briefing, "canceled" the room reservation and told the FEF that the senator "doesn't want anything to do with your organization." Actually, as *Fusion* Washington editor Marsha Freeman wrote in a letter to the *Post* editor, it was pressure from *Post* journalists badgering the senator and others on Capitol Hill that forced the cancellation of the room. The reason given by Lugar's office, politely reported to the FEF, was that that the senator "only reserves rooms for groups based in Indiana."

Despite the *Post*'s lobbying, the briefing on the SDI occurred at another location with two dozen press and congressional offices present. The *Post* declined to print Freeman's letter to the editor.

LT. GENERAL ABRAHAMSON: 'INCREDIBLE TECHNICAL PROGRESS'

Lt. General James Abrahamson, head of the Strategic Defense Initiative, told the American Institute of Aeronautics and Astronautics April 9 in Washington:

"It has been a year of incredible technical progress, and a year of rather amazing intellectual effort. The beam defense program is moving "so much more rapidly than even myself, a technical optimist, believed could have happened."

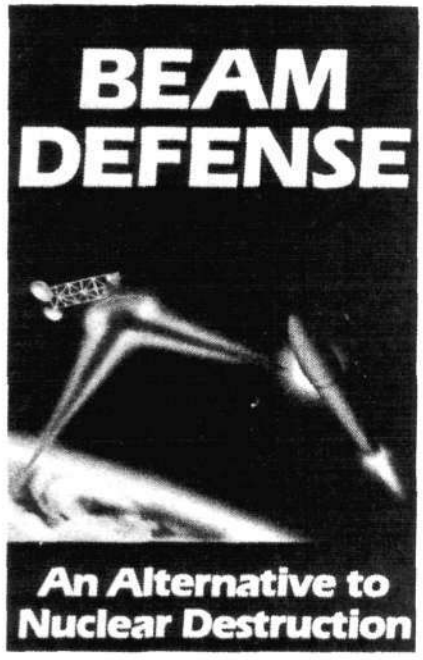
POPE REASSERTS MAN'S 'LORDSHIP OVER NATURE'

In a visit to the Center of Italian Space Telecommunications March 24, Pope John Paul II took a firm stand in reasserting man's "lordship over nature." Referencing the injunction found in Genesis 1:28 to "Be fruitful and multiply; dominate the Earth and subdue it," the Pope told the workers, "Therein is indicated above all God's intention of entrusting man with the task of self-realization, conquering with his labor a true lordship over nature."

This means, he said, that "man can be himself and achieve the purpose of his life, through the assiduous commitment to transformation of himself and an operational intervention into the world around him: overcoming obstacles, projecting new conditions of existence, procuring the necessary goods for the body and spirit. . . ."

NAVY LEAGUE CITES FEF'S *BEAM DEFENSE* BOOK AS THE 'DEFINITIVE TEXT'

The 1985 edition of the Navy League's *Alamanac of Seapower* in its review of various books on the subject of strategic defense states that although several books are basic explanatory texts, they "do not come close to the authenticity of the 1983 FEF's *Beam Defense*, which will remain the definitive text for some time." *Beam Defense: An Alternative to Nuclear Destruction* was published by Aero Publishers and won the top award last year of the Space/Aviation Writers Association.



The 'definitive text': The FEF's award-winning book, Beam Defense.

FEF BRIEFS THAI OFFICIALS ON THE BEAM DEFENSE PROGRAM

Fusion Energy Foundation research director Uwe Parpart Henke gave a seminar on the U.S. Strategic Defense Initiative in Bangkok April 18 to 80 representatives of the National Defense College, the Interior Ministry, the Special Branch of the Thai Police, and the Soviet and American embassies. During the question period, a Soviet representative asked, "Why bother investing in beam defense if it does not provide 100 percent protection?" Henke replied that since the Soviets thought the system was not feasible, why worry?

100 ATTEND FEF BEAM DEFENSE CONFERENCE IN ROME

A conference on beam weapon defense organized by the Fusion Energy Foundation and the Schiller Institute in Rome March 29 was attended by 100 military, industry, and diplomatic representatives. Among the participants were officials from the defense ministry, which has formed a new defense commission to study the areas in which Italy can contribute to the U.S. Strategic Defense Initiative. Speakers included Dr. Jonathan Tennenbaum, head of the FEF in West Germany, Michael Liebig of the *Executive Intelligence Review*, Italian FEF director Dr. Giuseppe Filipponi, and Prof. Forrest Tierson of the U.S. Space Foundation. Tierson told the Italians that President Reagan's offer of technology transfer to the Europeans is "a real offer," which Europe should accept quickly.

LOUSEWORT LAURELS TO THE U.S. INTERIOR DEPARTMENT

This issue's Lousewort Laurels award goes to the U.S. Interior Department for its March 15 decision to shut off the irrigation water to 42,000 acres of farmland in the western part of California's San Joaquin Valley. The ostensible reason for cutting off water to the nation's single, most productive agricultural-producing county in cash-value terms ($1.2 billion annually) is that the water runoff from the Valley violates the international treaties protecting migrating wild ducks. The problem is that minerals and other impurities from the agricultural waste water in the Valley flow into the Kesterson Reservoir and its wildlife preserve. Of course, the reason this occurs is that environmentalists prevented a 1970 plan to drain the waste water into the Pacific Ocean.

Greens Show Their Nazi Colors

There have been no limits to the praise in the Soviet press for the West German Green Party and its violent campaign against the U.S. military presence in Europe and the beam defense program. "A party of hope," the Soviets called the Greens after their latest election victories. Similarly, the Eastern Establishment media here have lauded the Greens as a benign political force against the Reagan administration.

While these fairy tales abound, the Green Party has bluntly admitted that it is a fascist party with a specifically Nazi ideology. "The Greens are rising to power in a way quite similar to the pattern of the Nazi Party," Green Party leader Rudolf Bahro told the Green Party congress in Hamburg, Dec. 8, 1984, in his keynote speech. Another leading Green spokesman, Rainer Langhans, announced: "All of us want total war against the system. In this respect, we can still learn something from our brother Hitler."

Like their "brother Hitler," the Greens have begun to win some elections. The Greens won 8.5 percent of the vote in elections to the European Parliament on June 17, 1984, replacing the Free Democratic Party (FDP) as the third largest party in the country. Four of the seven Green deputies elected have terrorist backgrounds.

The Greens also won 9 to 16 percent in municipal elections in the state of North-Rhine Westphalia on Sept. 30, and similar percentages in more recent elections. Commenting on the Green electoral victories, the *New York Times* characterized the party and its rejection of Western culture as the "wave of the future."

A Fascist Mass Movement

The Green Party was begun in 1979 by the Club of Rome as the electoral arm of the fascist environmentalism movement, a legitimate veneer for terrorist support. The doctrines of the Green Party are a 1980s version of the program of the Gregor Strasser wing of the Nazi Party, updated by the "limits to growth" philosophy of the Club of Rome, which plans to eliminate 2 billion of the world's population by the year 2000. The Green leadership includes neo-Nazis like Herbert Gruhl, August Hausleiter, and Udo Reinhardt, as well as acknowledged terrorists and terrorist-supporters.

The hallmarks of Green Party ideology are those of a fascist mass movement. There is a blood-and-soil mystical worship of nature and "the people," a romantic flight from the modern industrial world back to preindustrial times, and a Dionysian counterculture of rock music and drugs.

Here is the political program of Rudolf Bahro, the East German emigré who was one of the founders of the Greens: "The only real alternative can be the construction of basic communities, consisting of a proposed maximum of 3,000 human beings. . . . These communities will unify themselves around a simple, 'steady state' mode of reproduction of their material foundations. They will produce their basic needs in nutrition, clothing, housing, education, and health care largely through their own work, deciding on specialized production for barter primarily to surrounding areas. . . ."

Not every Green sympathizer is a hard-core fascist, but under conditions of increasing political and economic crisis, the bad tendencies in each will be encouraged and rapidly grow worse. Punks now openly wear swastikas, and the radicalized part of the Green movement has adopted the street-fighting tactics of the Nazi brownshirts, the SA.

Green Terrorist Support

The Greens not only are fascist in ideology; they also are the support apparatus for the hard core of terrorists who are carrying out acts of violence

Steven Bardwell

"All of us want total war against the system. In this respect, we can still learn something from our brother Hitler." Here Greens demonstrate in Frankfurt against nuclear power.

and sabotage against German and American military facilities and personnel—with blessings from the Soviet Union.

Since early December, there have been scores of violent incidents, injuring many American soldiers and claiming the lives of French General René Audran and prominent German industrialist Ernst Zimmermann. The terror dovetails with the step-up in the Soviet propaganda campaign against the U.S. Strategic Defense Initiative. According to reports in the French *Le Figaro* newspaper, Zimmerman was coordinating French and German participation in the beam defense program.

The Red Army Fraction (formerly called the Baader-Meinhof gang) issued a "joint declaration of war" with the French-based Action Directe and the Belgian Communist Combatant Cells Jan. 15, the same day a U.S. military social center in Brussels was blasted by a Combatant Cells car bomb, injuring two guards and extensively damaging the building. The Communist Combatant Cells group has struck some five or six times over the last few months in Belgium, blowing up a NATO emergency fuel pipeline in December. Papers found in raids on RAF safehouses in July 1984 included Zimmermann's name on a hit list as well as plans for the subsequent attacks on the NATO school in Oberammergau and the Belgium pipeline.

Terrorist coordination has been evident for months, most clearly since the Dec. 4 initiation of a "hunger strike" by Red Army Fraction terrorist prisoners. The hunger strike, which kicked off almost a dozen terror attacks in West Germany alone, is endorsed by the Green Party. In fact, the Greens called for creation of "mediation committees" to be led by none other than convicted Red Army Fraction terrorist Brigitte Heinrich, now representing the Greens in the European Parliament.

Heinrich was part of a Green delegation that visited the Mideast in December, meeting with the terrorist Palestinian organizations PFLP and PDFLP and with the foreign minister of Syria; they were also scheduled to visit the Bekaa Valley, the most important center of Islamic terrorist and illegal drug operations. The Israeli government, however, denied the Green delegation a visa, citing Heinrich's terrorist role. She was jailed in 1980 to serve a 21-month sentence for supplying weapons to the RAF.

Stuart Lewis

"The Greens are rising to power in a way quite similar to the pattern of the Nazi Party," Green Party leader Rudolf Bahro proudly told the Green Party congress in his keynote speech. East German emigré Bahro is shown here addressing a Sept. 1983 New York meeting of the N.Y. Committee for Marxist Education.

The Israeli ambassador to Bonn, Yitzhak Ben Ari, went even further and accused the Greens not only of terrorism but of reverting to a primitive form of antisemitism: "We live in the illusion that racism and antisemitism in this country are of no significance. The so-called strategy paper of the Greens teaches us otherwise."

The Greens have insisted that the Federal Republic give in to the demands of the Red Army terrorists, who are threatening the "execution" of 10 West German political leaders, including Chancellor Helmut Kohl, if a single hunger striker dies. In support, the Greenies threatened a total blockade of the Ministry of Justice. On Jan. 31, a Green delegation—Party leaders Antje Vollmer, Christa Nickels, and Burkhardt Mann—met with Klaus Kinkel, State Secretary in the Ministry of Justice, to present the terrorist demands in the name of the Green Party.

A few days earlier, after a nuclear power plant tower in the town of Kruemmel was blown up Jan. 25 by antinuclear terrorists, the Greens endorsed that attack. Thomas Wueppensahl, district chairman of the Green Party as well as an official in the state police, went on television to declare that he could, "after giving the matter some thought, quite fully approve" of the bombing. It is, he said, "self-evident that such ways of acting will now occur because that presents the only way" in which the "political movement will be accepted as part of the discussion of nuclear energy."

Where the Money Comes From

Despite their electoral gains, the Green base of support in West Germany is very small. How then are they supported? All evidence points to the Soviets and leading international terrorism coordinator Muammar Qaddafi. One West German government source put KGB support at several hundred million marks each year in order to spread disinformation on nuclear energy to "mobilize the population against nuclear power plant facilities." Other government sources say that the Soviet Union is spending $23 million a year in support of the Greens alone.

Last November Green leaders met in Bonn with a delegation from the Supreme Soviet, headed by Lev Tolkunov. After these discussions, the Green leadership met on its own to discuss "international solidarity," "revival of extra-parliamentary activities," and "the question of armed struggle."

As for Qaddafi, there are long-time ties with the Greens, and he has poured millions internationally into so-called peace movements. "I judge the Green movement in Germany as very positive. . . . I hope that out of the Green movement a movement for the liberation of all of Germany will also unfold. You must find new methods of struggle against oppression in Germany," Qaddafi said in November 1983.

Ban the Greens!

The Fusion Energy Foundation has been warning about the fascist danger of the Green Party for the past five years. In 1981, when space scientist Krafft A. Ehricke toured West Germany with the FEF speaking about nuclear and space development, gangs of

Continued on page 17

WHAT RECOVERY?

The United States Is a Postindustrial Nation

The United States is now in a depression far more serious than the Great Depression of the 1930s. Pathetic rhetoric about a so-called recovery aside, the figures for the basic economic indicators leave no doubt that this is the case.

U.S. heavy industry has been mothballed or destroyed, with entire sections of steel, power, and machinery operating at below 1972 levels of capacity; the industrial workforce has dropped sharply as a percentage of the total labor force; output per member of the labor force has dropped by more than half in the last 10 years alone; and individual household debt has doubled over the last seven years—just to look at a few indicators.

In short, the United States has become an economy that no longer produces even what it consumes. The seriousness of the situation is underscored by the fact that the Soviet economy has continued to grow.

While certain political figures and government agencies continue to puff the "recovery," the Soviets have had no such illusion about the U.S. economy. In a Moscow television show March 30, produced for internal Soviet consumption, "American specialist" Georgii Arbatov summarized the discussion of the U.S. economy bluntly. "The Americans themselves will not survive, so to speak, I mean economically," Arbatov said.

The figures comparing Soviet output to U.S. output over the past 10 years bear out Arbatov's analysis: Soviet production of goods—from tractors to refrigerators—is going up, while U.S. production is plummeting (Figure 1).

This is nothing short of a national emergency.

Because the figures are so startling and, in general, are covered up by official reports from the various government agencies concerned, we have reproduced here some of the data compiled by the weekly *Executive Intelligence Review* (EIR) for its Quarterly Report this spring. This report uses the LaRouche-Riemann economic model and a method of economic analysis developed jointly by the EIR and the Fusion Energy Foundation.

American System Economics

The yardstick used in this model to measure economic growth is that of Alexander Hamiliton in his outline of the American System of political economy presented to Congress in a December 1791 report "On the Subject of Manufactures." Hamilton, like the American System economists who followed him, believed that "people are wealth." To make the economy grow and the nation prosper required "the increase of the productive powers of labor" through technological progress in capital-intensive, energy-intensive modes of development of agriculture, industry, and basic economic infrastructure.

By this measure, gambling casinos, service jobs, and real estate speculation, whose growth is used today to

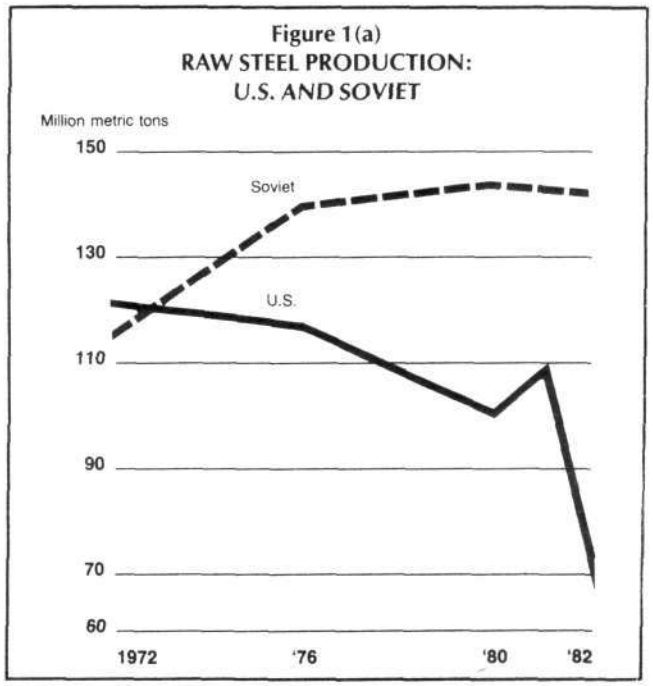


Figure 1(a)
RAW STEEL PRODUCTION: U.S. AND SOVIET

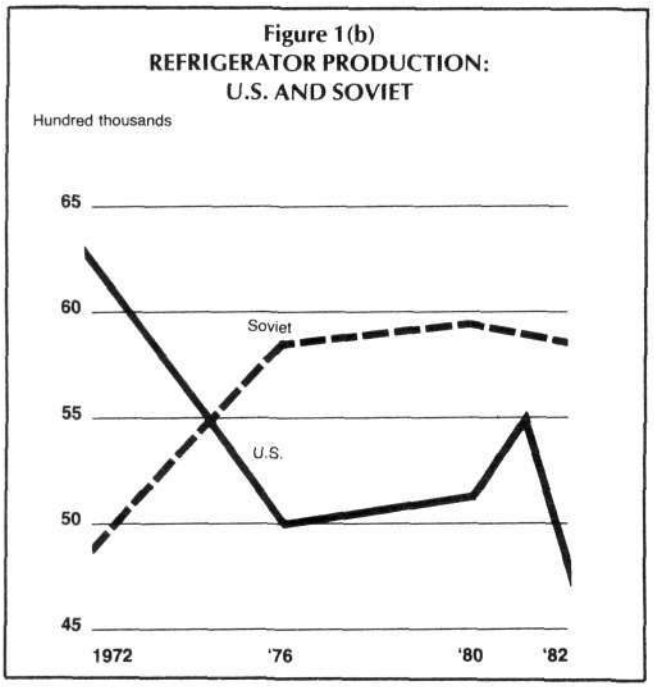


Figure 1(b)
REFRIGERATOR PRODUCTION: U.S. AND SOVIET

puff the so-called recovery, contribute nothing to the real economy.

LaRouche's contribution to this American System approach is the concept of increased potential relative population density. In other words, what is the average number of persons who can be sustained on an average square kilometer of land, at any given level of technology, solely by the productive activities of that population's labor force component. The key measure here is the rate of increase of the potential population density that can be achieved in terms of a defined level of technology. In the LaRouche-Riemann model, it is the variable rate of increase of this potential, by the spread of advances in employed technology, that is the yardstick for the health of an economy.

RAW STEEL PRODUCTION—60% OF 1973 RATES

(in thousands of tons)

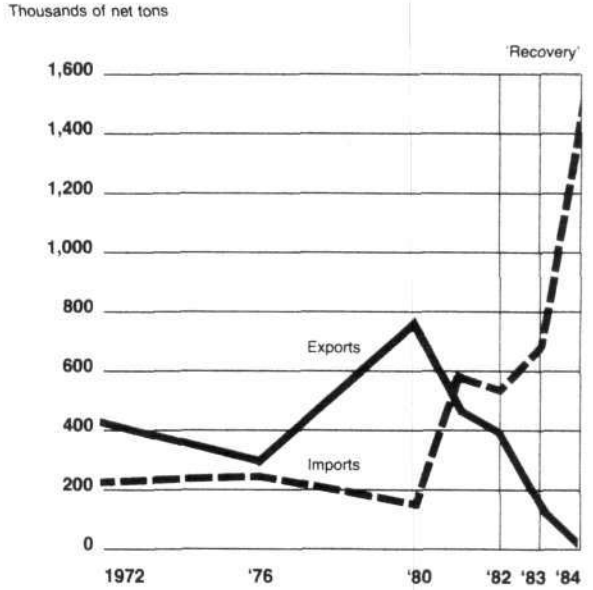
	Output	%1973 Output
1973	150,799	100.0
1976	128,000	84.9
1980	111,835	74.2
1981	120,828	80.1
1982	74,577	49.5
1983	84,615	56.1
1984	91,000	60.3

Source: AISI Statistical Reports

No More Steel Making

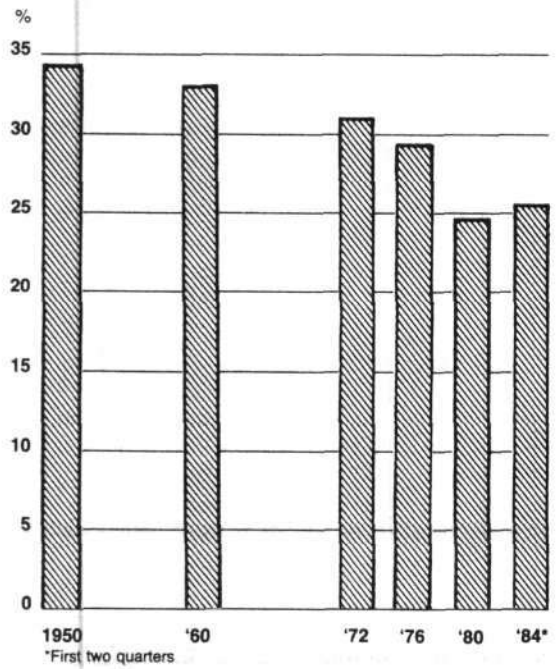
Last year, as much as 50 percent of the finished steel consumed in the United States was either imported from abroad or produced from scrap remelted in "mini-mill" recycling plants. The United States produced only 48 million tons of finished steel in 1984—barely more than during World War I. Of the 98 million tons of finished steel consumed here, 48 million tons were produced at home, 26 million tons were imported, and 24 million were the result of recycling scrap. U.S. steel capacity is now at most 70 million tons, or less than half the 160-million-ton capacity of 1974, and lower than any time since 1931.

Figure 2
FROM NET EXPORTER TO NET IMPORTER OF RAW STEEL



Source: American Iron and Steel Institute Statistical Reports

Figure 3
GENERAL INDUSTRIAL WORKERS DROP SHARPLY AS PERCENTAGE OF TOTAL LABOR FORCE



*First two quarters

The Wrecking of The U.S. Industrial Workforce

The destruction of the productive powers of the U.S. labor force is tantamount to a national security threat. Even the most casual comparison of the U.S. workforce to the Soviet Union's makes this point. By 1972, the Soviet Union, still a relatively agrarian country, had pushed its industrial workforce to 47.4 million, nearly twice that of America, at 26.8 million, although its total population is only 20 percent larger than ours.

The Soviets' ratio of industrial workers to total workers in the economy grew to 38 percent in 1972, surpassing that of the United States, which had fallen from 34 percent in 1950 to 30 percent by 1972. The U.S. industrial workforce has continued to decline during 1984 and 1985, despite claims of a falling unemployment rate by the Federal Reserve. The U.S. percentage of industrial workers to total workforce declined to 25.8 percent, while the Soviet figure reached 45 percent or more.

Figure 4
U.S. OUTPUT PER MEMBER OF LABOR FORCE DROPPED BY MORE THAN HALF

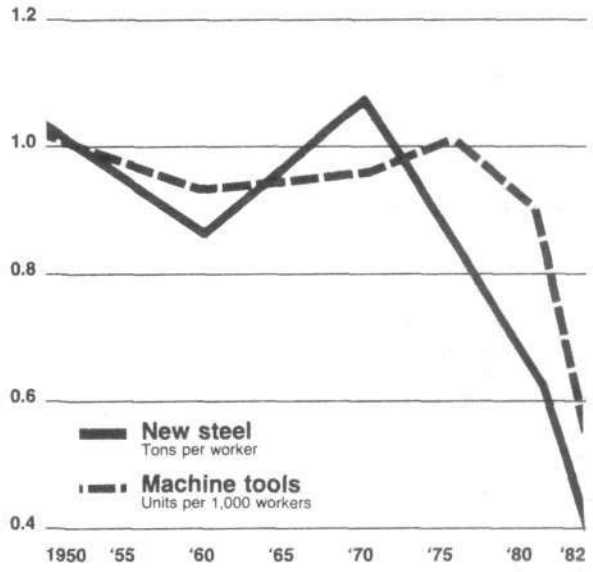
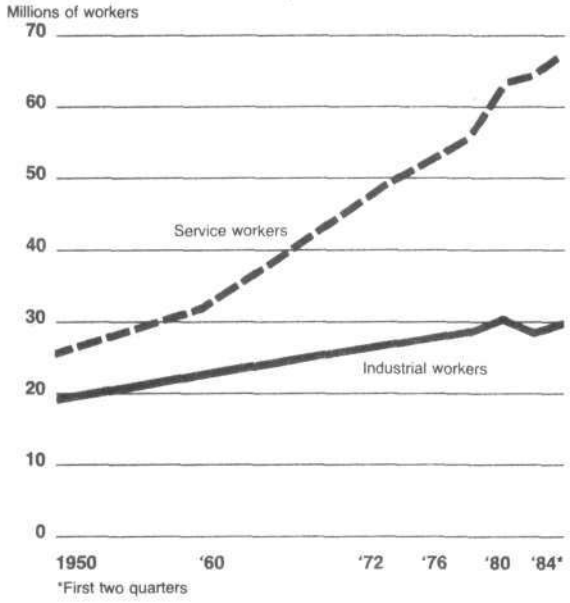


Figure 5
SERVICE JOBS MORE THAN DOUBLED AS INDUSTRIAL JOBS STAGNATED



Postindustrial Production

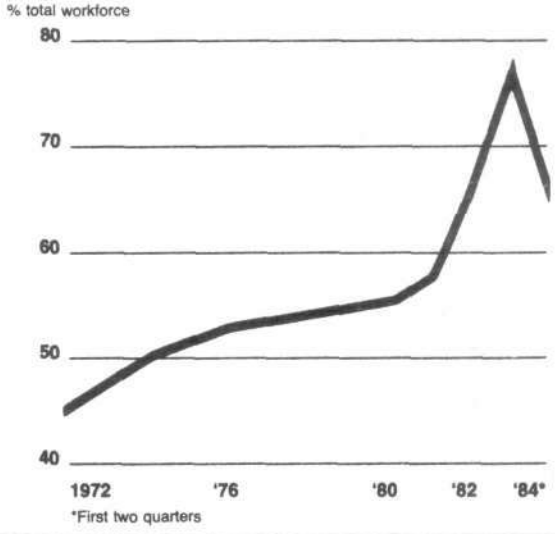
The basic indicator of whether any economy is functioning correctly is the percentage of the workforce engaged in goods production. At minimum, 55 percent of the workforce should be producing goods for the rest of the population. By these standards, the United States has fewer than half the industrial workers it needs. We no longer produce what we consume.

The economy is adding service jobs, but what kind of an economy is it when the industrial producers of goods are fewer than half the number of those who "service" them?

Another indication of postindustrialization is the recycling of the workforce. Of the 29.2 million industrial workers still employed, as many as 10 million, almost one third, lost their jobs at one point since 1978 and were recycled to lower-skilled jobs. The portion of the labor force employed part time to make ends meet is rising astronomically, from 12.4 million in 1972, to 18.4 million in early 1985. Twenty percent of all non-farm workers in the United States today do not have a full-time job—about 65 percent of the industrial workforce.

About half of the part-time workers are women, and 75 percent of them are not earning extra money, but supplying a second income in a family where the main breadwinner can no longer support the family.

Figure 6
PART-TIME WORKERS SOAR TO MORE THAN HALF OF THE U.S. INDUSTRIAL WORKFORCE



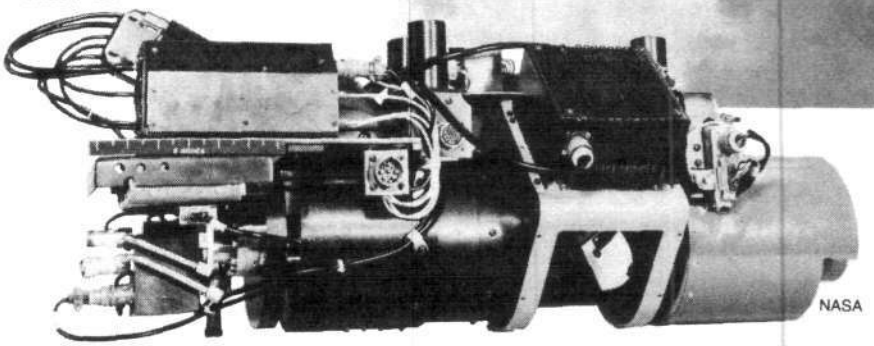
Living Off Import Welfare

Imports are not the cause of the loss of U.S. production but the replacement for what the United States is unable to produce. In 1984, 65 percent of all the radio and TV sets Americans bought was imported; 27 percent of all the parts and components that went into American-brand cars was imported; 26 percent of all steel consumed was imported; and 27 percent of apparel and other mill products was imported.

The biggest scandal concerning imports is the American car. While the Reagan economics staff claims that American auto production went up to 7.7 million units last year, if one reduces this amount by the content of foreign parts in supposedly American cars, one finds that American domestic car output totaled a scant 4.62 million autos, almost 1 million less than were produced in 1929!

Between 35 and 40 percent of all American cars are made up of parts, accessories, and components that are "sourced" from abroad and imported.

There's no technical reason for not detecting and destroying illicit drug fields! A multispectral scanner placed on the underside of the wing of a jet plane can detect drug plants by sensing their particular radiative signature. The remote sensing system designed for Mexico was able to cover 12,000 square miles of land per day. Shown here is a Gates-Learjet airborne platform; inset is a multispectral scanner made by Texas Instruments.



NASA

Let's Use Our Technology To Wipe Out Drugs

More than $400 billion of illegal drugs are grown worldwide each year. It is absolutely possible, using remote sensing technologies, to locate these illicit drugs, so that they can be destroyed before they are harvested, processed, and on their way to killing the minds and bodies of a significant number of our population.

Between 1972 and 1982, the U.S. government, in a joint program of the State Department and the National Aeronautics and Space Administration, developed new remote sensing techniques that were proven successful in locating illicit drugs. Airborne sensing systems, combined with Landsat satellite data, could pinpoint all significant opium poppy, cannabis, and coca crops worldwide.

The fact that this search system is not being used, even in nations like Mexico and Colombia, which have asked the United States to help them in their war on drugs, is a purely political decision. If the United States decides to escalate its current war on drugs to include searching for and destroying the crops in the ground, it can activate the international agreements and remote sensing systems already available to accomplish the task.

Remote Sensing Capabilities

The United States and Mexico signed a Memorandum of Understanding March 29, 1978, to develop an "advanced airborne data collection and ground data processing system for use by the Mexican government in identification of opium poppy fields in Mexico." A total of $7.5 million was allocated for this effort.

The program, called Curb Illegal Narcotics or CIN, ran for two years, during which time the system was developed, Mexican pilots and ground teams were trained, and the identification of the drug crops was proven successful.

The sensing system consists of a multispectral scanner attached to the underside of the wing of a jet plane. The scanner detects drug plants by sensing its particular radiative signature. Every growing plant, when hit by sunlight, reflects back radiation in a specific array of frequencies that is different from every other plant; thus the scanner can identify the signatures of illicit drugs.

For example, cannabis plants can be detected in the 1.55- to 1.75-micron band of the infrared part of the electromagnetic spectrum, its specific, identifiable signature.

The remote sensing system designed for Mexico was able to cover 12,000 square miles of land per day, or the entire country every 15 days. Because the cannabis plants grow for 120 days before harvest, this frequency of coverage allowed the program to "see" fields a few times before taking any action. During this period, Mexico was able to cut its heroin export to the United States from 14 tons per year to 1/2 ton per year, according to a U.S. official who participated in the program.

Despite the program's potential for eliminating a major source of illegal drugs, in 1982 the State Department cut off the funding for the recommended follow-on to the program, leaving the Mexicans with a remote sensing system they did not have the money to operate. For some tens of millions of dollars per year, this system now could be locating most of the illegal drugs in Mexico.

Colombia, the source now of approximately 60 percent of the mari-

juana and 80 percent of the cocaine illegally flowing into this country, was also cut off from funds to carry out the program after it was tested. In November 1980, the Colombian Minister of Justice requested information from the U.S. Embassy in Bogota about using remote sensing technology to determine the scope of illicit cultivation of cannabis and coca as a prerequisite to initiating a herbicidal eradication program. After the feasibility of using the remote sensing technology to aid the Colombian effort was demonstrated, no follow-on program was funded.

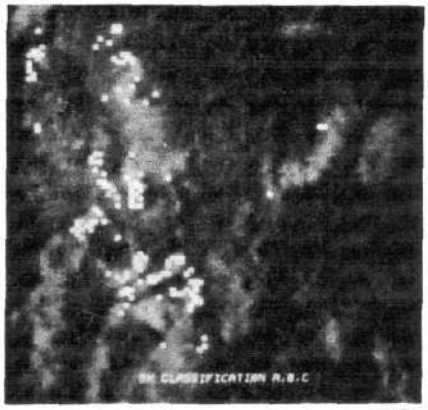
The foreword to the 1980 Final Report by NASA on the Curb Illegal Narcotics project states that at the end of the program, "all scientific and technical aspects of the project have been successful by both governments." The benefits of using the technology "had scarcely begun to be fully realized" at that time, the report notes.

"Perhaps the real success," the report notes, "lies in the mutual cooperation, respect, and trust realized by this merger of NASA technology, Department of State foresight, and Mexican talent and desire to excel. The two nations have opened new doors for the transfer of technology, and both nations have benefited."

What a contrast to the recent war of words being waged against Mexico by the State Department, which has charged Mexico with a lack of seriousness in fighting drugs. Although this destructive, lying campaign has been stopped as the White House—specifically through Attorney General Ed Meese—has escalated the war on drugs, there has as yet been no move to dust off the Advanced Poppy Detection System sitting in Mexico and use it to go for the kill.

In many of the nations of Ibero-America the governments themselves are heavily committed to the war on drugs, the growth of crops is illegal, and many of the drug-traffickers are therefore using smaller plots that are partially hidden. To win the war against drugs in this situation, airborne sensing systems that fly only a few thousand feet above the ground are necessary to obtain high resolution.

In other nations, like Iran and Pakistan, where the governments either sanction or ignore the growing of illicit drugs, the fields are so large that they can be identified by space-based Landsat systems that have a lower resolution. If both the Landsat and the airborne sensing systems were put to full use in a military mission to search and destroy drug fields, all significant illicit drug fields could be located.



NASA

Marijuana fields are shown in white in this computer-enhanced scanner photo.

LaRouche: War Mobilization Necessary

To eradicate drug traffic in the Western Hemisphere, requires a military war plan. This is exactly what FEF board member Lyndon H. LaRouche, Jr. proposed in a 14-point program presented at a March 14 conference in Mexico City sponsored by the *Executive Intelligence Review*: "We must declare war on the pseudogovernment of the international drug traffickers, and we must fight that war with the weapons of war—and win—in the same spirit with which we fought for the unconditional defeat of Nazism," LaRouche said.

LaRouche proposed a treaty of alliance for conduct of war between the United States and the Ibero-American states that join the war on drugs. He also proposed that the United States supply countries with technologies appropriate to detection of growing, processing, and transport of drugs, including satellite-based and aircraft-based systems. As soon as the growing of a relevant crop is confirmed for any area, he said, military airborne assault should be deployed immediately to destroy that crop, and the same policy should be followed for drug processing centers.

LaRouche further specified that the banks and other institutions that are elements of this drug quasi-state should be classed as outlaws according to the "crimes against humanity" doctrine elaborated at the postwar Nuremberg Tribunal.

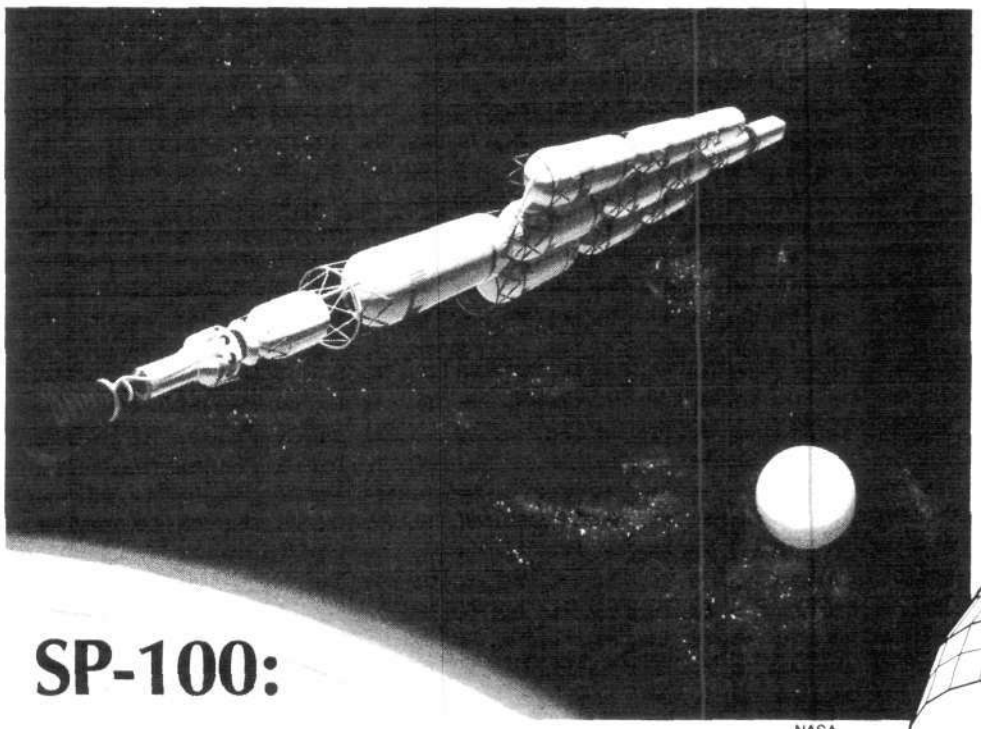
—*Marsha Freeman*

Reagan, Betancur Issue Statement On Drug Eradication

Colombian President Belisario Betancur met with President Reagan April 4 to review "the drug scourge" and what the two nations could do to "combat the production, trafficking, demand, and use of illicit narcotics."

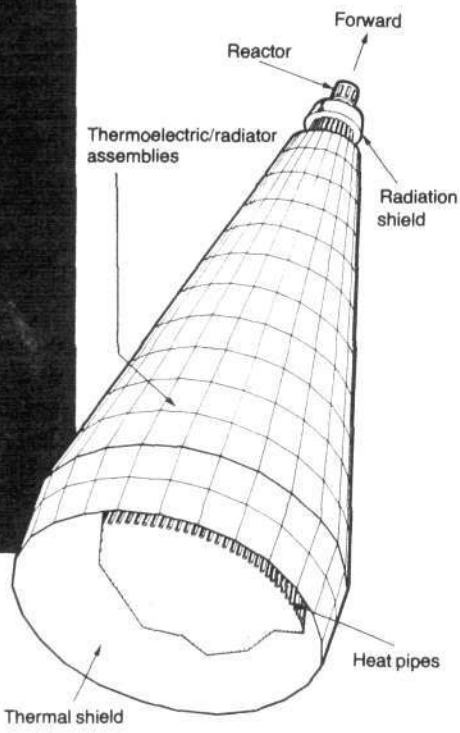
In a joint statement—largely ignored by the nation's press—Betancur and Reagan said: "Drug trafficking is a criminal activity that has no frontiers and can only be controlled by a combined effort of all countries involved. We have shared our concern that the financial power resulting from the enormous profits of illicit narcotics trade poses a terrible threat to democracy in the Americas. Our mutual dedication to the anti-narcotics struggle is an integral part of the close relations that exist between our two nations. We both see a vital need to enlist the cooperation of other governments in this intensified effort. . . .

"The cost of success in the past has been high. It has included the life of a Colombian cabinet minister, Rodrigo Lara Bonilla, and law enforcement officers from both countries. We cannot allow such sacrifices to have been in vain. We pledge to each other to revitalize and intensify our efforts to destroy the trafficking network. Our decision is irreversible, our dedication total. Nothing will deter us from this fight."



NASA

Artist's depiction in 1970 of an SP-100 nuclear rocket space station. Inset is a schematic of the SP-100 power system.



SP-100:

The Space Challenge To Nuclear Technology

by Marsha Freeman

The United States may have a second chance to commercialize breeder and high-temperature nuclear reactors, using new spinoffs from the SP-100 space nuclear program. These technologies were suppressed when the nation put its nuclear industry on the back burner, but now the SP-100 program is likely to spin off further advances in fuel and materials for high-temperature fission reactors on Earth.

The SP-100 program has a challenging mission: to design a nuclear plant small enough to fit in the payload bay of the Space Shuttle, powerful enough to deliver 100 kilowatts of electricity, and reliable enough to operate for seven to ten years without requiring any maintenance.

Under development by the Department of Energy and the National Aeronautics and Space Administration, the SP-100 program became a national priority in February 1983, when NASA, the DOE, and the Department of Defense signed an agreement to design and evaluate a 100-kilowatt space nuclear reactor.

The agreement includes a study, being carried out by the NASA Lewis Research Center in Ohio, to see "if a reasonable need for multimegawatt space nuclear power exists." If so, the agencies will "embark on a long range technology development program" in this higher power level range.

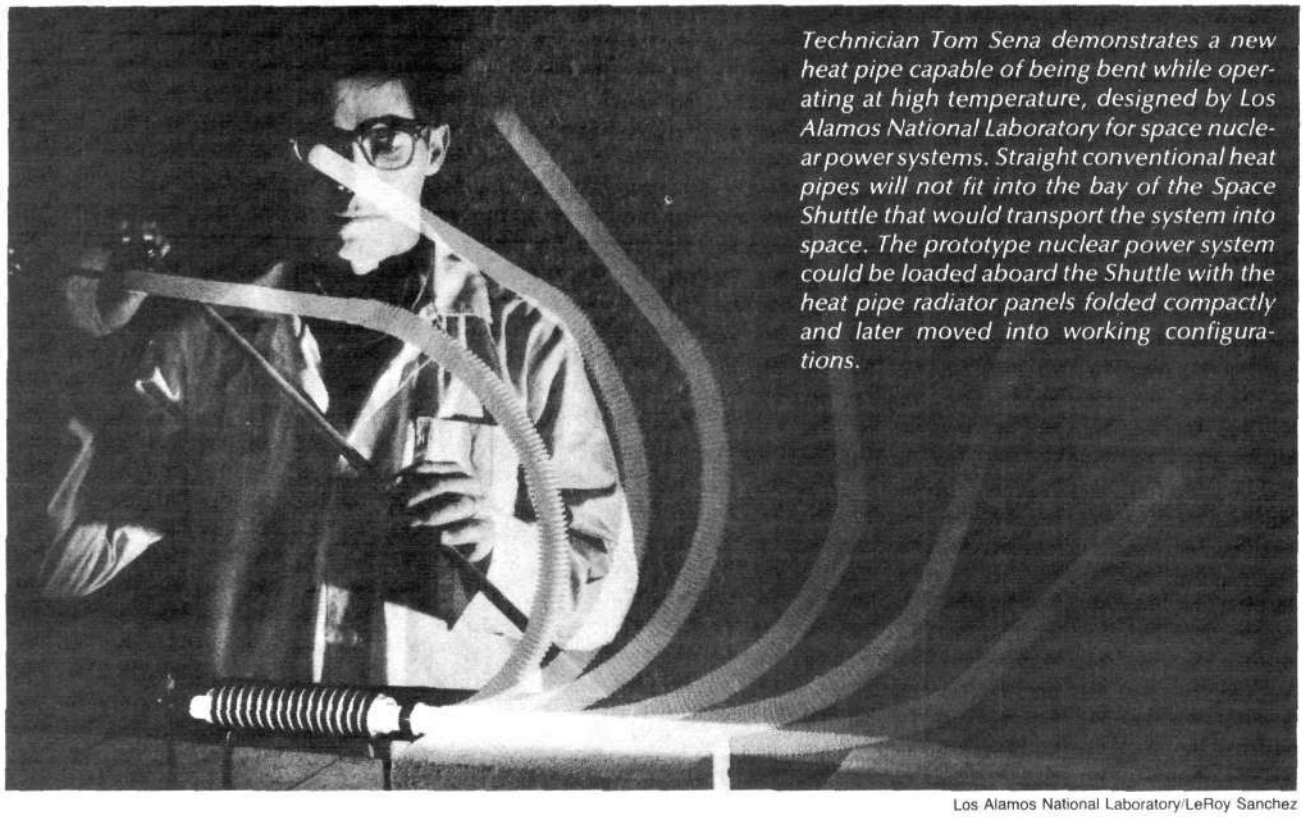
"We have to find ways to do it faster," General James Abrahamson, head of the Strategic Defense Initiative office, told the April 9 Washington meeting of the American Institute of Aeronautics and Astronautics. In July, the three agencies involved will decide whether to build a ground test reactor. As Abrahamson noted, the beam defense program will need multimegawatt reactors as soon as possible.

Nuclear power sources have been used in the planetary program for decades, where solar energy is too faint. Now the manned space program and military needs in space require further nuclear development.

Consider the first permanently manned space station, currently in its design stage at NASA. The early 1990s station includes solar panels to provide 75 kilowatts of electric power for light, cooking, water purification, and other human needs. It will also power scientific experiments, small-scale manufacturing systems, and other facilities.

As the station grows and new laboratory and other modules are added on, the power requirements will outstrip the reasonable capabilities of solar panels. To provide 20 kilowatts of power to the station with solar panels, 250 square meters of solar array are needed. A nuclear station can provide five times that power—100 kilowatts—with less than 100 square meters of area.

In addition, a nuclear plant will not



Technician Tom Sena demonstrates a new heat pipe capable of being bent while operating at high temperature, designed by Los Alamos National Laboratory for space nuclear power systems. Straight conventional heat pipes will not fit into the bay of the Space Shuttle that would transport the system into space. The prototype nuclear power system could be loaded aboard the Shuttle with the heat pipe radiator panels folded compactly and later moved into working configurations.

Los Alamos National Laboratory/LeRoy Sanchez

require any specific orientiation for the station, while solar panels always have to be pointed toward the Sun. Because solar arrays also increase the total area of the station, they increase its drag. The station gets slowed down by collisions with the atomic hydrogen and other particles surrounding it. (Space is not "empty.") The use of nuclear power means that less fuel will be needed to keep the station at its proper orbital altitude.

Big Nuclear Plants

With larger nuclear plants in space, the possibilities become even more exciting. Central power distribution is the most efficient way to power space industrialization. Why build every communications satellite, space station, and manufacturing plant with its own power supply, and why encumber larger space structures with huge arrays of solar panels, when centralized Earth-orbiting nuclear plants could efficiently service a whole complex of space infrastructure.

A large spaceborne electric utility producing at least 100 megawatts of power could convert the electricity to laser light or microwaves and transmit the energy to users in orbit. Microwaves could be used economically to transmit power up to 100 kilometers from the power base, if the user is outfitted with a 20-meter-long receiving antenna.

On the Moon, a 20-meter antenna could also be used to receive power while a permanent settlement was being put in place. Such a central power base in Earth-orbit could be about half the size of a football field, delivering 10 billion kilowatt hours of power over its lifetime.

Even before central power stations were in place, smaller nuclear reactors could be the power source for individual communications satellites. As the power is increased on the satellite, the stronger signal allows the use of a much smaller receiving antenna on Earth. If the on-board power is 50 kilowatts, for example, the Earth-based antenna would be 30 meters in diameter. If the power were doubled, the antenna would be reduced to a 20-meter diameter size. At even higher power levels, wristwatch-sized antennas could provide personal communications via satellite.

Nuclear-Powered Defense

President Reagan's announcement in March 1983 of a new strategic doctrine for the United States gave new purpose to the participation of the Department of Defense in the SP-100 program.

The military has short-term requirements for nuclear-powered space assets. Any military satellite is considerably more vulnerable with solar wings sticking out. The more compact nuclear reactor makes a smaller target.

In addition to more bulk, a solar technology system to produce 100 kilowatts of power would weigh at least 2.5 times more than a comparable nuclear reactor system. In contrast, a nuclear power plant could double its power output with only a one third increase in reactor mass. This reduces the launch weight and constraints.

The Soviets have had nuclear-powered radar ocean surveillance satellites for years (two came back through the atmosphere, one in 1978 and the other in 1983), but the United States has yet to orbit one. Even one spaceborne radar system could provide surveillance for the entire nation's defense against any air-breathing threats, such as aircraft.

Using tens of kilowatts up to megawatts of nuclear power, the system could provide for early warning of enemy ballistic missiles. And as the pow-

er of the radar signal increases, the antenna size goes down, making the satellite more difficult to spot. In addition, the number of "looks per second" for detecting targets would increase 80 percent over solar-powered systems, because the radar signal pulse rate would be so much faster.

Besides its obvious military applications, such a nuclear-powered space-based radar could "see" through clouds and be used for air traffic control, navigation for ships, and other civilian applications.

High-powered military space communications systems could produce a signal strong enough to "burn through" tactical energy jammers, and could also be used to power U.S. electronic jammers.

Laser and other directed energy systems that are pumped electrically, such as the excimer laser, could be fueled by nuclear-produced power as well as by direct nuclear pumping of X-ray lasers. These systems, which are the heart of the Strategic Defense Initiative, cannot be constricted to being a "nonnuclear" defense, as much as some of the antinuclear alleged supporters of the beam defense program would like this to be the case. The fact is, for General Danny Graham and others, the term nonnuclear actually means "non-beam-defense."

The Technology Challenge

A spaceborne nuclear reactor has to be small, compact, as efficient as possible, and robust. The SP-100 program is examining designs that would operate for seven to ten years without any repair or maintenance, reliably delivering 100 kilowatts of electricity. Industrial and national laboratory teams are doing studies on different designs for the reactor itself, the cooling system, energy conversion from heat to electricity, shielding materials, and power delivery—all of which will improve the technology available for Earth-based plants.

The SP-100 has to fit inside the Space Shuttle payload bay, with an upper stage attached to launch it into an orbit higher than one the Shuttle can reach. The total weight limit for the nuclear power plant unit is 5,500 pounds. The nuclear reactor itself will weigh less than 1,000 pounds, leaving 4,500 pounds available to additional systems. By far, the largest part of the power system is the radiator, which radiates waste heat in to space and contains the conversion elements. Lightweight carbon/carbon composites are being examined for this structure.

In space, there will be no steam turbines to convert heat to power. The thermal energy produced from the fission reaction will, in all likelihood, be converted directly to electricity, with no moving parts.

For this purpose, the Los Alamos National Laboratory has been developing high-temperature heat pipes to carry the reactor heat to thermocouples for power conversion (see photograph). Their reactor design operates at more than 1,400 degrees Celsius, which is considerably hotter than present terrestrial light water reactors.

Water will not be used to cool space reactors. The heat pipes could be filled with liquid lithium, which would evaporate from the heat, deposit its energy with the thermoelectric converters, condense, and be reused. Such a direct conversion technology in space requires the higher temperatures that nuclear heat can provide, because the efficiency of conversion increases with the temperature difference between the hottest and coldest materials.

New Materials

One of the greatest technology challenges of the SP-100 program is the development of new metal alloy and ceramic high-temperature materials to withstand hostile nuclear and space environments.

In-core thermionic direct conversion systems are also under investigation. Tungsten is cladded over the nuclear fuel element in one in-core design. These cells, located inside the reactor core, convert heat to electricity by "boiling" electrons directly off the metallic thermionic material.

Thermionic systems will have to operate in the 1,500 to 1,700 degree Celsius range to be efficient. At these very high temperatures, there are materials problems, swelling of the fuel element, and other difficulties that need to be solved. Today's thermionic converters, which use a silicon-germanium alloy, can operate only at a maximum temperature of about 1,000 degrees Celsius.

At that temperature, conversion efficiency is about 7 percent. Selenium alloys, developed for the converters in the radioisotope thermoelectric generator system for the Galileo probe to Jupiter, will bring the efficiency of conversion up beyond 10 percent. These radioisotope systems, called RTGs, produce heat as the plutonium isotope decays. The thermal energy is directly converted into electricity using thermocouples in which a voltage is created when two dissimilar metals are joined in a closed circuit, at different temperatures.

The limitations of the RTG system are that its temperature goes down as the isotopes decay, and that it has a power density of only 5.5 million electron volts per alpha emission from the decaying plutonium, while each fission of uranium-235 produces 200 million electron volts.

It is also possible that dynamic systems—such as Stirling engines, which do have moving parts—will be applicable to space requirements, and these kinds of systems are under investigation.

Technology Transfer to Earth

In 1977, the Denver Research Institute did a study for NASA titled, "Applications of Space Nuclear Power and Propulsion Technology" in which they examined the 18-year partnership between the space and energy agencies in research and testing of space power and propulsion systems to determine which developments could and were being applied to the civilian nuclear industry.

"Public policy has become the ultimate arbitrator of the applications for space technology in the civil sector," the study begins. Although this is still largely the case, because the federal government has failed to make nuclear development a national priority, the space nuclear projects of the previous generation indicate the potential technology transfer for the future.

The nuclear engine for rocket vehicle applications, the NERVA program, for example, gave the nuclear industry new materials, computer programs for testing safety systems, new instrumentation, testing techniques, high-temperature themocouples, special materials fabrication techniques, and the possibility of building lightweight

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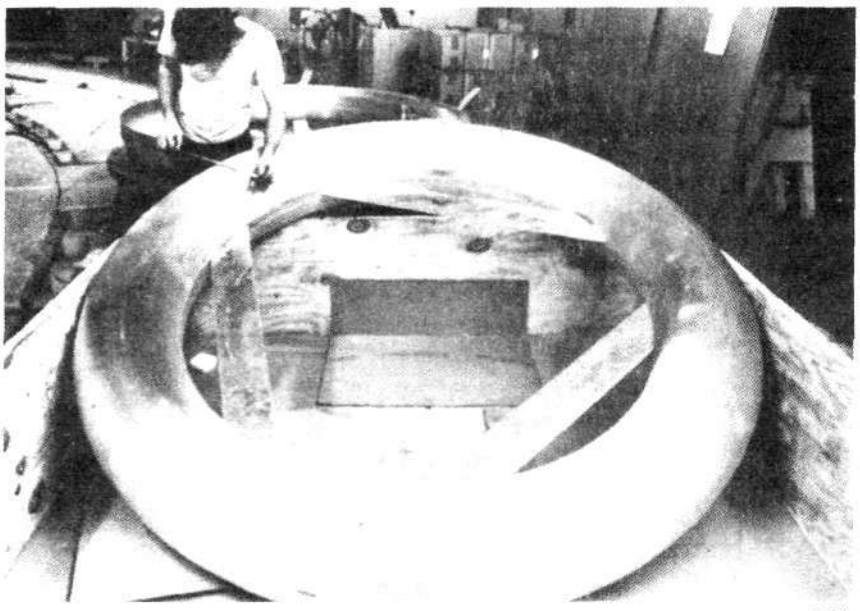
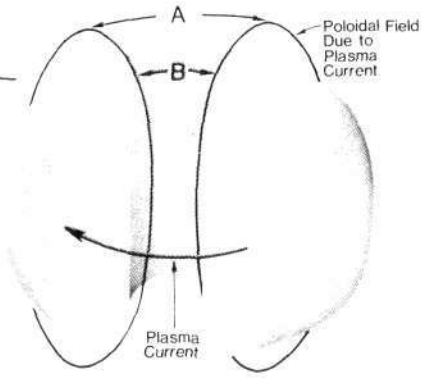


PPPL

The spheromak can be smaller and more efficient than the tokamak because it uses the electric currents within the plasma itself to generate the confining magnetic fields. This eliminates the necessity for external copper coils. Shown is the diameter of the vacuum vessel for the S-1 in construction. Inset is a diagram of the plasma configuration.



S-1 Spheromak Reaches True Plasma Operation

Researchers at the Princeton Plasma Physics Laboratory in New Jersey reported in February that they had achieved the initial goals set for their S-1 spheromak experiment. Despite some preliminary mechanical problems, the S-1 has now reached true plasma operation with temperatures above 1 million degrees Celsius (100 electron volts) and energy confinement times of about .001 second.

These results confirm the scientific principles of the spheromak, which were first demonstrated in 1983 on the Los Alamos National Laboratory's CTX spheromak.

The spheromak is the most promising advanced concept for economical and compact magnetic fusion reactors. In the near term, spheromaks have numerous potential applications to the development of pulsed power and directed-energy beam technology. The S-1 success is particularly significant because it proves the feasibility of an entirely different kind of spheromak from that of the Los Alamos CTX.

Self-Organized Magnetic Plasmas

To achieve fusion, hydrogen gas must be heated to 100 million degrees Celsius while being contained and thermally insulated to maintain the gas energy flux density. At these high temperatures ordinary matter becomes "electrified"—ionized—and is called plasma. Ionized plasmas interact strongly with magnetic fields such that the plasma can be stably confined and insulated within a properly designed configuration of magnetic fields—a so-called magnetic bottle.

The most successful magnetic confinement designs have utilized copper coils that generate the magnetic bottle when an electric current is passed through them. In the tokamak, for example, the magnets are placed around a donut-shaped vacuum chamber in which the hydrogen fusion fuel is injected.

The spheromak, and the compact torus more generally, improves on this type of approach by using the electric currents within the plasma itself to generate the confining magnetic fields. By removing the necessity for external copper coils, the plasma donut can be made much smaller and more efficient. In particular, because plasmas can be held together by electric currents, they can sustain much higher current levels than can conductors made out of ordinary materials. As a result, the spheromak offers a most efficient and economical means to achieve the high energy-flux densities that are essential for both fusion and directed energy beams.

Because the spheromak is a self-organized magnetic plasma, it can be physically removed from the formation chamber and moved about. Further, because the spheromak contains a very small amount of mass—a few millionths of a pound—confined within an intense magnetic field, it can be easily accelerated to hypervelocities in excess of 10,000 kilometers per second.

Such "translation" experiments have been carried out on the FRC compact torus at Los Alamos, and other spheromak translation experiments are being pursued at Lawrence Livermore National Laboratory in California. For power reactors, the ability to transport the fusion plasma, or plasmoid, can dramatically decrease the engineering problems and capital costs.

In terms of directed-energy beams, the hypervelocity spheromak is extremely important. The spheromak is made up of a small amount of mass and contains most of its energy within its confining magnetic field; therefore, it

offers one of the best means of readily achieving energy densification.

The plasmoid can be easily compressed and/or accelerated to high velocities near the speed of light with just a few yards of a simple, metal electrode shaped in the form of a funnel. The spheromak enters one end and is accelerated and compressed by an electric current that is passed through the conical (funnel) electrode. As a result, the plasmoid is compressed.

The self-confining magnetic field of the plasmoid plays two important roles in this energy compression process. First, it insulates the metal electrode from the heat of the plasmoid. Second, most of the energy amplification is taken up by the "compressed" magnetic field. The magnetization of the compressed energy provides many versatile methods for its later conversion to useful electrical energy, such as the acceleration of charged particle beams.

Traveling at a significant fraction of the speed of light the plasmoid could deliver a power flux on target in excess of 10,000 trillion watts per sqare centimeter. Alternatively, a highly compressed or accelerated spheromak represents a versatile technology for power amplification for driving other types of particle beams, lasers, and microwave generators. Lawrence Livermore is currently pursuing concepts for compression of electromagnetic waves with high velocity spheromaks to produce trillion watt microwave bursts.

Future S-1 Plans

The S-1 represents a qualitatively different approach to spheromaks from the Los Alamos CTX. The CTX is dynamically created with a plasma gun, while the S-1 is statically generated with a complex magnet core system. Success with both systems represents a substantial rate of progress in the science of compact tori.

In the near future, Princeton researchers will be attempting to decrease the size of the S-1 so that higher plasma electric current densities can be achieved. They will also be exploring the use of the dynamo effect found on the CTX, which could permit the spheromak to be sustained in a steady-state mode of operation.

—Charles B. Stevens

Greens Show Their Nazi Colors

Continued from page 7

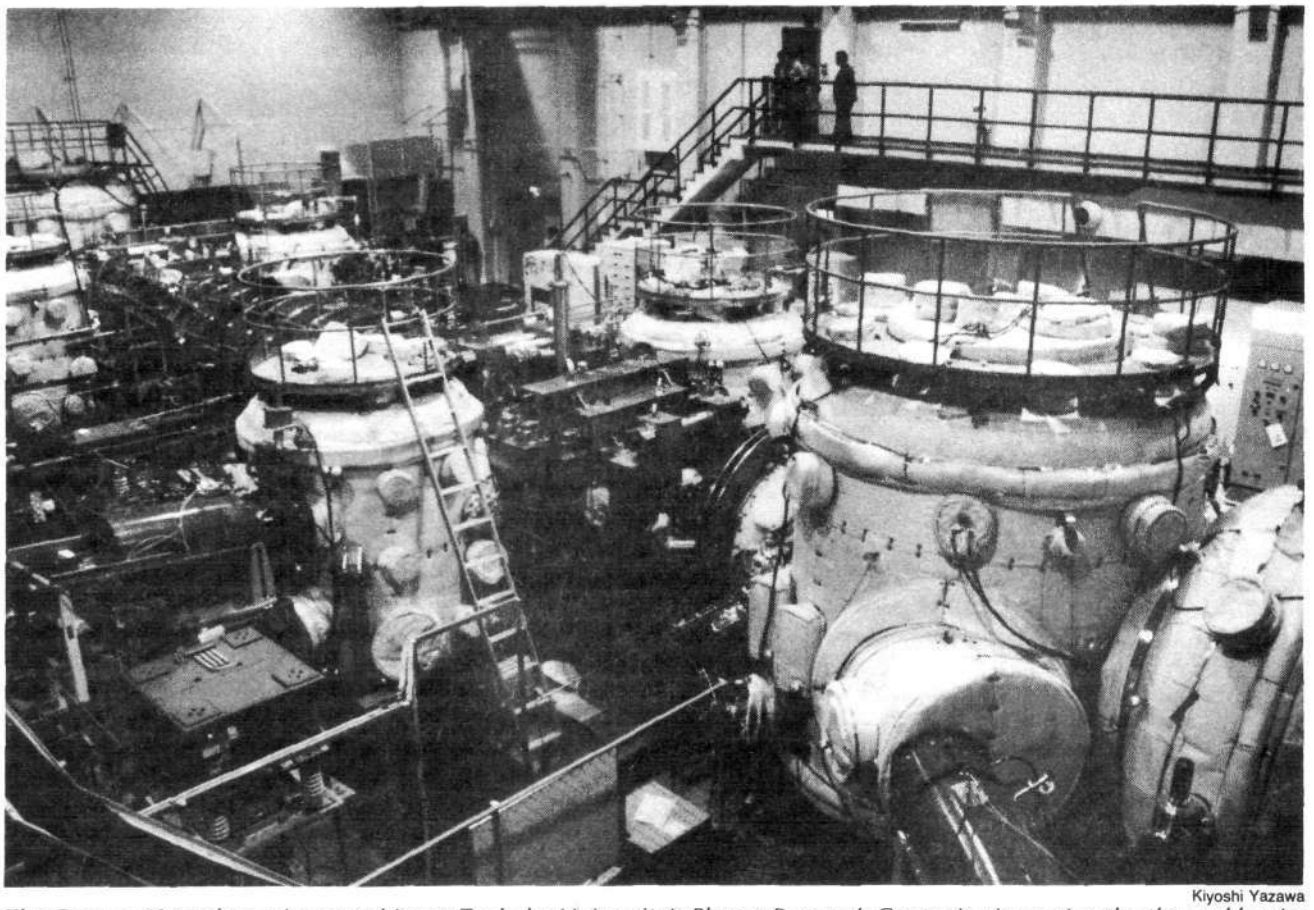
Greenies attacked the meeting sites. At a forum to support the construction of a nuclear power plant at Neckarwestheim, 40 rock- and bottle-throwing masked youth tried to prevent people from entering the hall. Back in the United States, Ehricke reported to his American audience how shocked he was to see again the same patterns he had witnessed as a youth in Berlin during the rise of the Nazi movement in 1929-1931.

Now that the Greens' true colors are out in the open, others have finally begun to speak out and call the Greens Nazis. Parliamentarian Heinrich Aigner, for example, said that the Greens were "leading the dangerous way back into the National Socialist policy of the 1930s. . . . Whoever paves the way into the parliaments for the Greens today makes himself as guilty as those voters who decided to have a try with Hitler in 1933."

Nevertheless, no vigorous political, legal, or police measures have been taken to stop the new Nazi menace, and the mistakes of the Weimar period are being repeated with frightening precision—including the invitations from the U.S. State Department for Green leaders to tour the United States. The European Labor Party, the international Schiller Institute, and the FEF have circulated a call for banning the Greens as unconstitutional under West German law. Time is running out, but such a move could still succeed if supporters of Western civilization move quickly.

—Catherine Caffrey Schapiro

Contributions to the Fusion Energy Foundation are tax deductible.



Kiyoshi Yazawa

The Gamma 10 tandem mirror machine at Tsukuba University's Plasma Research Center is pioneering the thermal barrier technique to produce energy breakeven in a mirror machine.

Japan's Gamma 10 Leads Mirror Fusion Work

This article by Fusion Asia editor-in-chief *Ramtanu Maitra is adapted from his special report on the Japanese fusion program, which appeared in* Fusion Asia *July 1984. Maitra visited the Gamma 10 facility in March 1984.*

* * *

The world's first tandem mirror machine, Gamma 6, began operation at Japan's University of Tsukuba in Tsukuba Science City in 1978, and its successor, the much larger Gamma 10, is now in its second year of experiments. The mirror configuration is one of the most promising candidates for commercial fusion reactors because it is geometrically simple and can hold a high plasma pressure. Plasma pressure is a critical measure for the power density of a reactor.

The main challenge of mirror confinement systems is to prevent the loss of particles (and associated instability) from the ends by "plugging" them to the point that confinement is sufficient to produce net energy in the plasma. The most advanced mirror plugging concept, now being studied in the Gamma 10, is the thermal barrier.

The tandem mirror program at Tsukuba, under the direction of Dr. Syoichi Miyoshi, head of Tsukuba's Plasma Research Center, includes a group of 13 physicists and 5 technicians. As Miyoshi explained, the Gamma 10 program has three principal objectives. The first is to create an axisymmetric configuration in order to reduce radial losses caused by nonaxisymmetric components of the magnetic field.

The second is to form a sloshing-ion density distribution in the end mirrors for improvement of microstability and to form hot electron rings near the midplane of the end mirrors to strengthen the plasma's macrostability. Hot electrons may be produced in the minimum-B region to further the magnetohydrodynamic (MHD) stabilizing power of the anchor, it is hypothesized.

Third, the Gamma 10 will attempt to form a thermal barrier between the plug and the central cell in order to reduce microwave power requirements for plug electron heating.

Gamma 10's Design

Gamma 10 is 27 meters long and weighs about 180 tons. Its magnetic field coil system is made up of 24 circular coils, 6 minimum-B coils (also termed baseball coils because their shape is the same as the seams of a baseball), and 4 racetrack coils—all of which are excited by five indpendent power sources.

How a Mirror System Works

The simple magnetic mirror works on the same principle as the Earth's magnetosphere works to prevent space plasma from reaching the Earth. The ionospheric plasma is trapped by the Earth's magnetic field, which increases in strength at the north and south poles. Given a magnetic field with two points of increased intensity, a plasma will always tend to be trapped between the two points.

The first theoretical concept of a mirror fusion reactor consisted of a cylindrical vacuum chamber and two magnet coils that slid up and down the cylinder. The two coils form magnetic fields that cause the plasma to "reflect" back—hence, the "mirror" machine. As the coils are moved together, they compress and heat the trapped plasma. As the plasma builds up energy from fusion reactions, it expands against the magnetic fields, inducing an electric current in the external coils. Thus, in principle, the mirror machine can convert fusion energy directly into electricity, without the intermediate step of heating steam for a conventional turbine.

However, this simple mirror system has one major problem—a phenomenon known as end loss and the instability associated with it. The individual plasma electrons and ions are trapped into spiral orbits along the magnetic field lines and when they approach the region of increased magnetic field intensity, they are reflected back in the opposite direction. Some particles, however, primarily the lighter electrons, do not get reflected and instead escape through the ends of the cylinder. In fact, the simple mirror system experiences such extensive end loss that without modification it is incapable of producing energy breakeven.

The electrons and ions that are lost have specific velocity distributions. The ratio of their velocity along the magnetic field lines to their spiral velocity is greater than some determinable value. This value, if graphed in three-dimensional velocity space, will define an upside-down three-dimensional cone. All the particles within this cone area are lost out the ends of the cylinder.

Once the plasma is trapped in the mirror, the only way particles escape is through collisions that change their velocities such as to put them into the loss cone described above. In plasmas, the electrostatic field of the plasma as a whole is mainly responsible for collisionlike changes in individual particle velocities. Further, this effective collisionality decreases with increasing temperature—a fact that has been used in designing an effective end plug.

The Tandem Mirror

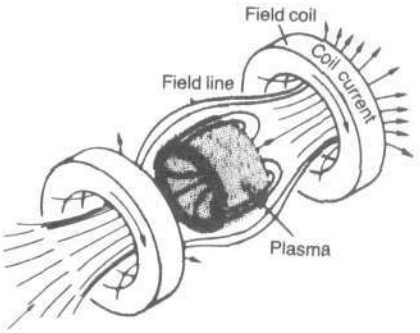
Modifications of the simple mirror system that have kept mirror fusion in the running for commercial power development have been undertaken in various laboratories. The tandem mirror system—developed independently by researchers in California and Siberia in 1975, and first built by Japan in 1978—is the most promising of the modified systems to date.

In the basic tandem mirror system, high-energy neutral beams are injected at both ends of the cylinder to increase the plasma temperature there, and thus decrease collisionality and block end losses. At the same time, the pressure difference between the central and end-plug mirror regions of the plasma caused by the heating—a difference that by itself would exacerbate the end losses—is offset by the simultaneous establishment of a positive electrical potential in the end-plug region, which acts to confine ions in the central region. The net effect is a great reduction in end losses.

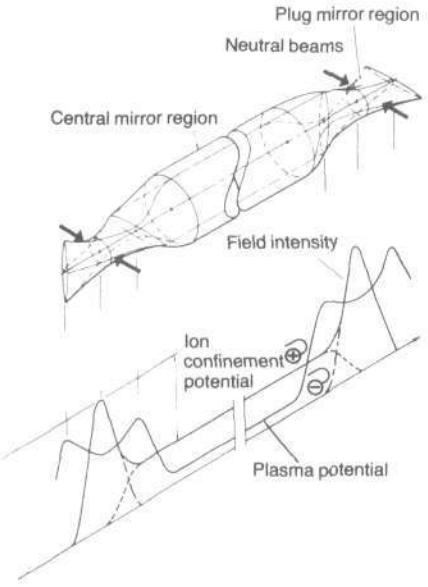
In addition, the neutral beam heating is complemented by magnetic field coil configurations at each end of the central solenoidal magnet coil. The magnetic field geometry of the "end plugs," the minimum-B field coils, acts to prevent macroscopic or magnetohydrodynamic (MHD) instability caused by whatever leakage does still occur. The minimum-B fields stabilize the plasma by creating a magnetic field or "well" that increases in every direction from the plasma center.

The tandem mirror configuration has a number of additional advantages. The simple cylindrical configuration that traps the fusion plasma in the mirror and end plugs makes the construction of a reactor much easier and potentially less costly than other systems. Also, the simplicity of the mirror design means that modular construction can allow easy access and repair.

SIMPLE MIRROR MAGNETIC FIELD



TANDEM MIRROR MAGNETIC FIELD



In the simple mirror, the lighter electrons escape out the ends of the cylinder. In the tandem mirror concept, the injection of high-energy neutral beams changes the confinement geometry, greatly reducing end losses.

Kiyoshi Yazawa

Dr. Syoichi Miyoshi, director of the Plasma Research Center, discussing the Gamma 10 with Fusion Asia *editor Ramtanu Maitra.*

The central coil solenoid is 175 centimeters in mean diameter and is capable of producing a magnetic field of up to 6 kilogauss. A 60-centimeter diameter ramp coil, which produces a magnetic field of 30 kilogauss, is placed at each end of the solenoid, followed by two transition coils bordering the minimum-B coil. An axisymmetric mirror coil, which yields a maximum magnetic field of 32 kilogauss, is then placed at each end for MHD studies and thermal barrier development.

The device will be capable of confining plasma with a temperature of 1 kiloelectron volt and a density of 10^{13} particles per cubic centimeter in the central uniform magnetic field region. But to attain this combined temperature and plasma density in the central cell, the end losses have to be reduced and the macroinstability that is associated with the end losses needs to be overcome. This is the purpose of both the elaborate end plug systems at each end of the central cell and the particular improvements in these systems the Gamma 10 has introduced.

Unique Characteristics

In Gamma 10, the electrons in the outer hill of the sloshing-ion distribution are heated to a few kiloelectron volts to produce a high potential barrier of about 2.5 kilovolts to confine central-cell ions. To facilitate formation of confinement potential, Gamma 10 also generates a thermal barrier between the end plug, where neutral beam injection is used to reduce end losses and the central cell by means of electron cyclotron resonance heating.

This region of low potential acts to reduce the movement of electrons and to control the thermal flow from the end mirror coils, which yields a maximum magnetic field of 32 kilogauss. This thermal barrier is expected to create sufficient confinement potential without providing high plasma density for the plug mirrors. It is expected thus to reduce the technical difficulties that arise in the use of neutral beams and strong magnetic fields to generate and maintain the end cell plasma.

Gamma 10's other innovation is axisymmetrization. Once the mirror is plugged at each end by means of potential confinement, the end loss drops sharply. But the focus shifts to the radial leakage of particles—by means of resonance diffusion, among other modes—which had earlier been ignored.

Experimental evidence has confirmed the theoretical prediction that a significant fraction of central cell ions suffer cumulative radial drift as they reflect axially in nonaxisymmetric regions. The resonant radial diffusion driven by this mechanism can be expected to be a significant loss process as axial confinement time is improved with thermal barriers in a nonaxisymmetrized system.

To counter this problem, Miyoshi and his associates have added an axisymmetric mirror field to the minimum-B fields. The entire device is made effectively axisymmetric in the sense that any ion reflection is designed to occur only at axisymmetric regions. Thus, the stability of the entire plasma is secured at the same time that ions are confined to the central system.

Encouraging Results

The results of the Gamma 10 experiments are most encouraging. Myoshi emphasized that during the electron cyclotron resonance heating pulse, the flux loss decreased dramatically at one end of the machine, although it increased slightly at the other end. At the same time, a slight increase in the central cell line density was observed.

The experiments included using a combination of neutral beams and gyrotrons at one of the axisymmetric end cells. Neutral beams are injected into each anchor and into each end cell. The former is to produce hot ions for MHD stability, while the latter is to create sloshing ions for plug/barrier formation. The existence of sloshing ions was noted, and the end loss fluxes and plug potentials were measured with end loss analyzers.

The plugging experiments were carried out after the decay of gun-produced plasma and during the period of neutral-beam-sustained plasma. Electron cyclotron resonance heating was pulsed for 2 milliseconds to clarify the combined effect. Energy analysis of the loss fluxes showed that the plug potential increased up to more than 300 volts during the plugging and that central cell ion temperature rose by several tens of electron volts. Because the plug cell density is almost equal to the central cell density, and the average electron temperature in the plug cell is a few times larger than that in the central cell, a conventional Boltzmann relation between density and confinement potential does not hold.

These results clearly point to the formation of a thermal barrier and plug potential in the axisymmetric end mirror.

Computer Programming Breakthrough Brings Real Time to Beam Defense

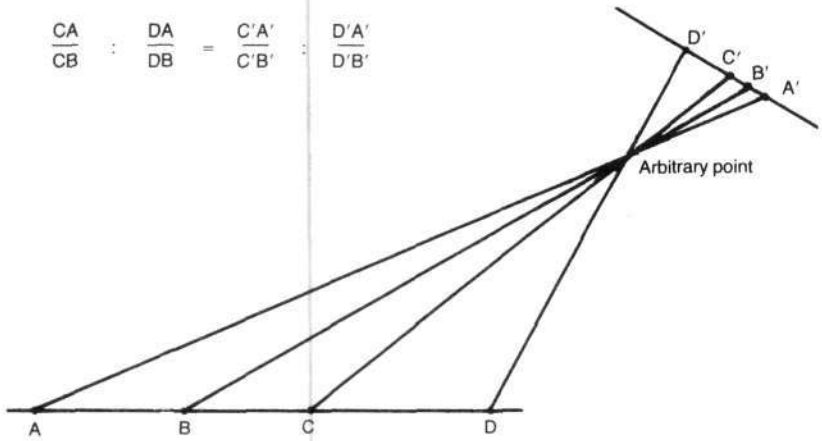
For more than two decades the power of computers has been increased every year by about a factor of 2. This steady advance in computing power has been almost entirely the result of improvements in computer hardware—smaller and faster circuits, and so on. Now a 28-year-old Indian-born mathematician, Narendra Karmarkar, working at Bell Laboratories in Murray Hill, N.J., has achieved a fundamental breakthrough in the science of computer programming that promises to vastly accelerate the evolution of computer capabilities.

Although there has been significant coverage on this breaking development in the national press, the initial reports have not pointed out what leading experts have reported to this publication: Karmarkar's discovery will revolutionize defense capabilities, in particular President Reagan's Strategic Defense Initiative (SDI).

The area of computer programming in which Karmarkar has made his breakthrough is that of linear programming, the most utilized type of problem solving found in industry and defense computer applications. Until now, solving linear programming problems depended upon the simplex method developed by Dr. George Dantzig of Stanford University, which was restricted to a step-wise, algebraic counting procedure.

Karmarkar's method, in contrast, involves a nonalgebraic, synthetic geometry approach that generates a minimal path to the desired solution. In particular, Karmarkar uses a series of projective transformations and the invariance of the cross ratio to create a sequence of points that converges to the optimal solution (see figure).

Karmarkar's new method has already been shown to be 50 times faster than the existing algebraic simplex method in direct comparison runs. On larger problems, the Karmarkar's method promises to be exponentially faster. Laboratory spokesmen said that they are about to release detailed data on comparison runs using the Karmarkar discovery. They expect large-scale application of the breakthrough to begin by the end of 1985, and the Defense Department is already discussing the development and its military applications.



CROSS-RATIO INVARIANCE

Karmarkar took a nonalgebraic, synthetic geometry approach to problem solving that depends on the fact that the cross ratio remains invariant in projective transformations. Cross ratio is the fundamental concept of projective geometry, just as length is the fundamental concept of metric geometry. Cross ratio is not a ratio of lengths, but a ratio of ratio of lengths. For the four points above, A,B,C,D, on a line, the cross ratio equals

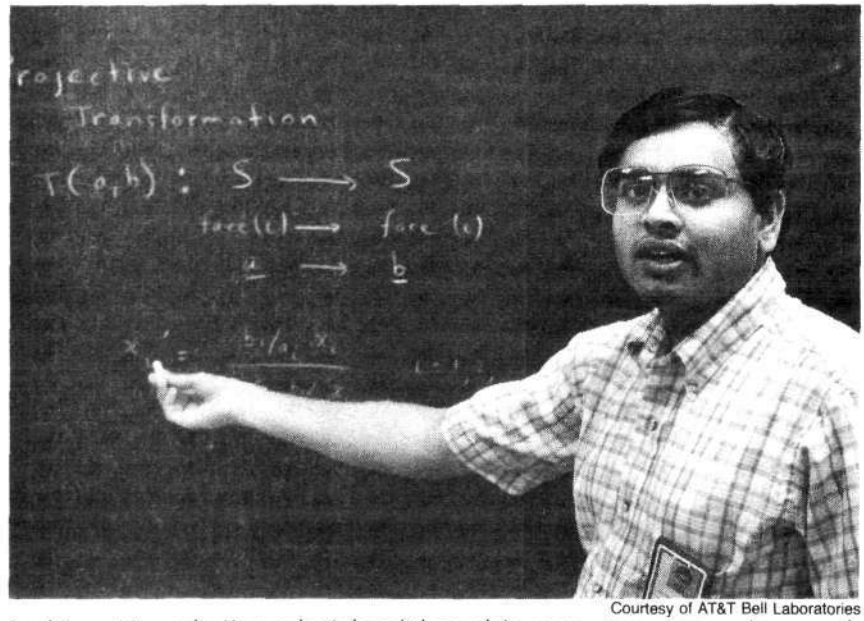
$$\frac{CA}{CB} : \frac{DA}{DB}$$

If the line containing points A, B, C, D is projected to another line, then corresponding points A', B', C', D' will have the same cross ratio as points A, B, C, D on the original line.

Linear Programming

Linear programming is the most general type of problem found in business, industry, and defense. For example, in running a factory or an airline, one would have numerous types of inputs that must be put together in the correct proportions to make the system perform smoothly and efficiently. Linear programming consists of combining these input variables with linear equations that represent their functional interrelationship in order to find an optimal operational configuration.

In the simplex method, the problem is represented as a three-dimensional solid whose corners represent potential solutions. Each of the corners is examined by the computer to find the optimal solution. This search process is restricted to traveling along the edges of the solid. In contrast, using projective geometric transformation, Karmarkar creates an entirely new path through the interior of the solid to the



Courtesy of AT&T Bell Laboratories

Real time: Narendra Karmarkar's breakthrough in computer programming speeds up problem-solving so that the computer produces solutions before new data inputs are received.

optimal solution corner.

In the worst case, the simplex method could involve examining all of the corners of the solid. Geometrically, the number of corners is determined by taking the number 2 to a power equal to the number of variables in the problem.

In other words, the number of computations needed to solve linear programming problems with the simplex method can grow *exponentially* with the number of variables involved. With the Karmarkar geometric method, the number of calculations grows only in direct proportion to the number of variables involved.

A Military Revolution

Leading defense computer scientists have suggested that Karmarkar's breakthrough will revolutionize all areas of military technology, in particular meeting most of the computer needs of President Reagan's SDI program for developing beam weapon defenses against nuclear weapons. The key point emphasized by these specialists and by Karmarkar himself is that the breakthrough so speeds up computer problem solving that problems can be solved in real time. That is, the computer produces the solution before new data inputs are received. This will make radar, sonar, and various other target pointing, tracking, and acquisition systems much more self-reflexive and interactive.

One leading expert reports that the breakthrough could revolutionize submarine detection. Long-range submarine detection is primarily based on the ability to simulate with a computer the ocean's interaction with sound waves. In this way submarines can be detected over ranges of thousands of miles. But even with the largest computers, the computing time takes several hours with present methods. Karmarkar's breakthrough promises to reduce this computer time by a factor of 100. Thus the submarine could be detected within an area of several hundred square miles instead of an area of 100,000 square miles. Air-dropped, local sonar detection would then pinpoint the exact location of the sub.

Reducing computing time to real time will have the most dramatic impact on missile defense. Let's take the Navy's Aegis missile defense system for large carrier task force groups. Because existing computer systems are not fast enough to analyze and absorb all the potential radar data that are actually received on a real time basis, the Aegis system consists of methods developed to minimize the amount of data that must be analyzed to find specific targets.

For example, all ship radars are interconnected by a single, integrated computing system, and radar sensors are used on the antimissile missiles themselves to minimize the amount of radar/computing time that must be utilized to find a specific target. In this way the number of missiles that the task force could detect and destroy coming from any location was raised from a level of 6 missiles per second to about 100 missiles per second.

The Karmarkar development promises to improve this capability by many orders of magnitude, because by going to real time, the more accurate, narrow radar beams will be able to be directed at targets. Now, because of the slow computing time, radar beams have to be used in a general sweep mode.

Specific Beam Weapon Applications

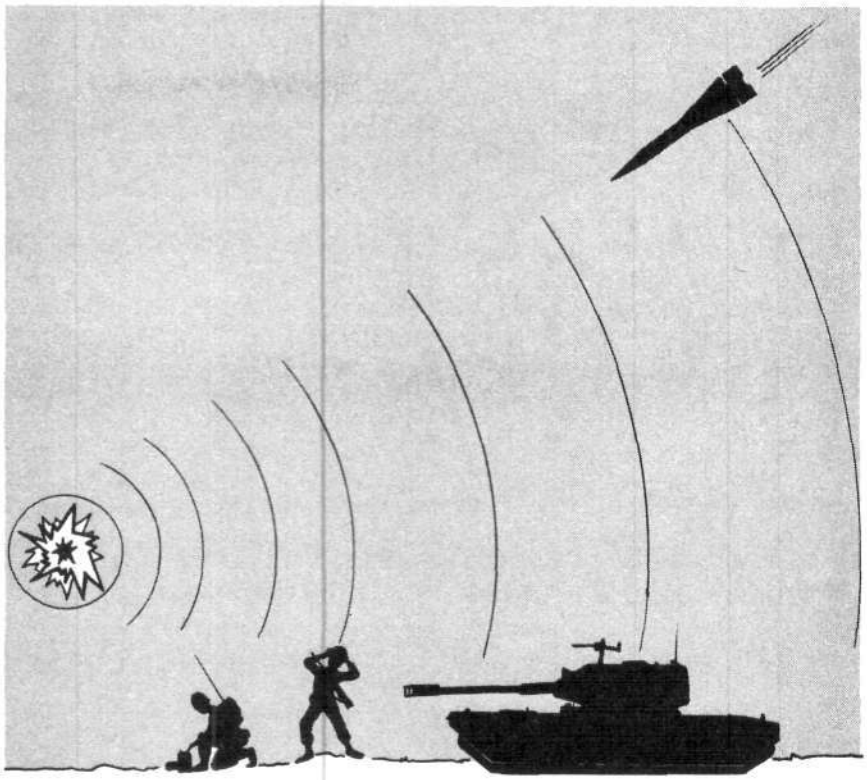
Here are some of the specific applications of the Karmarkar breakthrough for beam weapons:

Pattern recognition in real time. This means that only a minimum amount of sensor data inputs—radar, infrared, or visual images—would be needed to distinguish friendly forces from decoys or enemy forces.

Calculating missile trajectories. Present missile tracking capabilities are based upon either guessing the general missile trajectory or using a great deal of sensor capability to sweep large regions of space and thus keep the missile under observation. Real time computing will make the utilization of sensor systems far more efficient, permitting the tracking and targeting of tens of thousands of missiles and warheads with a minimal deployment of sensor capabilities.

Targeting and automatic pilots. Computational times currently limit the rate and accuracy of targeting. Making computation real time will immensely increase both accuracy and the numbers of targets that can be intercepted during a given period of time. Automated pilots are not fully realizable now because of the bottleneck in computing time. Real time computation will make true automated pilots feasible for the first time, thus greatly improving the effectiveness of all types of missile interception, whether antimissile missiles or beams.

—Charles B. Stevens



Microwave Bomb Under Study By Air Force for Beam Defense

The tight security wraps on microwave bombs, one of the most potent systems for defense against nuclear missiles and for general military applications, were lifted briefly, when the Air Force officially confirmed Jan. 7 that it had awarded a contract to study the bomb's possible development. Mission Research Corporation of Santa Barbara, Calif. was awarded the contract, according to Lt. Ray Cornelius of the Air Force Armament Division at Eglin Air Force Base in Florida.

Until the Air Force confirmation of a one-sentence news item that had appeared in *Defense Daily* Jan. 4, the very name mircrowave bomb, let alone any R&D on the concept, was never mentioned.

There is a wide range of military applications for microwave bombs, or m-bombs. At lower power flux levels, the m-bomb can disrupt electronics; at higher levels, microwaves can cause physical destruction. As m-bombs are further developed, it will be possible to tune their output to achieve the most efficient means of destruction for a particular target.

Although m-bombs can be used in an offensive fashion, they will be most effective for the defense. The reason is that offensive systems, like ICBMs, must move over great distances at high speeds to be effective. To attain locomotion requires a connection between the interior and exterior of the system, and this connection provides an efficient path for the microwave beam to follow and destroy the offensive system. This is readily seen in the case of rockets and jets, where the "connection" takes the shape of a large exhaust plume.

With nuclear m-bombs, the defensive potential is truly immense. As Dr. Lowell Wood of Lawrence Livermore

National Laboratory recently told Congress, as reported by *Defense Daily*, "One contemplates the functional (and perhaps physical) destruction of entire fleets of ICBMs with a single weapon module lofted by a single defensive missile."

Plasma Technologies

The microwave bomb, or m-bomb, is based on the mastery of advanced plasma energy storage, conversion, and concentration processes. Plasma is an electrified state of matter. When a gas is heated to thousands of degrees Celsius, electrons normally trapped within atoms become stripped away from them and are free to move in any direction.

Contrary to popular mythologies concerning entropy and the so-called destructive effects of extremely high temperatures, plasma is potentially more highly organized and versatile than other states of matter. In particular, plasmas are capable of storing energy in great concentrations, at the same time efficiently transforming it into coherent forms and amplifying it. This means that plasmas can do work more efficiently than any other nonliving medium.

Since high-temperature plasmas also provide the means for igniting thermonuclear fusion reactions, plasmas will eventually become the general medium for almost all forms of industrial production. Some years ago, this concept of plasma processing was put forward as the fusion torch, a device that can take any material input—rock or garbage, for example—and generate any desired output in the form of coherent energy and pure chemicals, with a minimum of waste and virtually no unwanted by-products.

In fact, the technology for processing the radioactive wastes from nuclear fission reactors in a plasma torch has already been realized.

Principles of the M-Bomb

The m-bomb is based on the the same principles involved in the general concept of the fusion torch, but in this case the desired output is a powerful burst of coherent microwaves. Although microwaves are a less energy dense, longer wavelength form of electromagnetic energy than that emitted by visible wavelength lasers, for example, the same fundamental principles of plasma dynamics can be extended to any portion of the electromagnetic spectrum.

This can be seen in the case of the free electron laser or FEL. Unlike previous types of lasers, in which the generation of coherent laser light depends on utilizing the highly organized electron orbits in atoms, the FEL uses high-energy beams of "free" electrons and intense magnetic fields to achieve lasing.

At present, the electron beams and magnetic fields for FELs are generated by machines constructed of ordinary materials. Ultimately, however, the best medium for both magnetic field and beam production is that of plasma. Unlike ordinary materials, plasma can efficiently maintain virtually any known level of field intensity. This is because magnetic and electric fields are the primary means of holding a plasma together.

In ordinary materials, on the other hand, chemical bonds hold things together. When exposed to intense magnetic and electric fields, these chemical bonds disintegrate, and the configuration falls apart. In plasmas, just the opposite occurs. Intense electric and magnetic fields generally only increase the potential strength and organization of the plasma structure.

For this reason, plasmas are the best medium for efficient generation of intense magnetic fields and electric fields needed to accelerate electrons to extremely high energies. More significantly, plasmas can provide the essential means to stabilize and concentrate intense electron beams. Unlike ordinary matter, which appears to interact primarily on the basis of individual collisions among atoms, high-temperature plasmas become collisionless; the interactions of its individual constituents are mediated through the total electromagnetic field.

Therefore, it becomes possible for an extremely intense, high-energy electron beam to reside within a plasma without having its energy dissipate as heat. The plasma and beam do interact, but only in terms of the overall electromagnetic field. This type of plasma dynamics is called magnetohydrodynamics (MHD). If properly managed, the plasma can act as a stabilizing buffer on a resident electron beam in a manner similar to that of firemen holding a firehose to stabilize the water flow.

Using this type of stabilizing buffer interaction involves only a very small margin of the energy flow of an intense electron beam. However, directing a slight change in the plasma parameters—for example, in the way in which its temperature or pressure is distributed—can lead to dramatic changes in the beam-plasma configuration. Such changes lead to several different possibilities, one of the most common being the generation of a burst of coherent microwaves.

As the plasma state is further mastered, it will become possible to extract almost any desired wavelength of electromagnetic or particle beam energy desired. Unlike existing systems that can produce these forms of coherent energy, plasma-based processes promise to achieve far greater energy concentrations at far greater efficiencies. The m-bomb is therefore only just the beginning.

Specific Designs and Applications

It is important to note that microwave bombs can be powered either by ordinary chemical explosives or by nuclear weapons. In both cases a significant fraction of the total energy produced by the explosive can be converted into microwaves, and in some cases the actual power density of the explosive can be greatly amplified in the resulting microwave burst. With chemical explosives, the initial energy is generally used to generate a large electrical current, which is then used to create a plasma. The plasma then produces the microwave burst.

With nuclear explosives, there are a number of different paths. It is possible to utilize an arrangement similar to that of the chemical m-bomb, or to directly use the plasma generated by the explosion itself. Alternatively, the primary radiation output of the nuclear explosion can be used to create and drive microwave generation in an external plasma. This last method occurs naturally with space-based nuclear explosions, because the Earth's upper atmosphere and magnetic field offer the requisite configuration for microwave generation—the so-called electromagnetic pulse or EMP effect.

—Charles B. Stevens

James Stoots, Jr./LLNL

The electron beam of the Advanced Test Accelerator at Lawrence Livermore remained well focused within the laser-generated plasma channel, even when the magnets were turned off.

Shown here is the ATA electron injector. The technician is testing the water feed line just beyond the final accelerator module. The vertical black pipes are transmission lines that deliver 250-kilovolt, 70-nanosecond pulses to individual accelerator modules. In the injector, an electron pulse travels down the cable to a cold cathode disc, similar to a light bulb filament, creating a plasma of electrons. These particles are then injected into a region of strong magnetic field that accelerates the electron to 2.5 million electron volts.

A 'Wire in the Sky' That Will Revolutionize Beam Weapons

A new concept called Antigone, or "wire in the sky," would make possible the propagation of well-focused charged-particle beams through space. The beam would propagate through space in a plasma channel generated by a pulse of laser light, which would act as a wire and charge-neutralize the beam, thus permitting it to be well-focused. Because charged-particle beams are thousands of times more effective than laser beams in destroying missile warheads, this will revolutionize beam defense.

The Antigone experiments were carried out by scientists at Lawrence Livermore National Laboratory using the Advanced Test Accelerator electron beam, according to Dr. Louis Marquet, director of directed energy weapons for the Defense Advanced Research Project Agency. Marquet said that previously it was thought that charged particle beams could not be based in space. The positive ions or negative electrons in such beams, it was thought, have a mutual repulsion that will cause the beam to blow up and fly apart before it propagates a few feet in the vacuum of space.

In the Livermore Antigone experiments, benzene gas was introduced into the accelerating vacuum chamber of the Advanced Test Accelerator, and a laser pulse then produced a plasma channel through the gas. It was found that the accelerating electron beam remained well focused within the laser-generated plasma channel even when the focusing magnets of the accelerator were turned off.

Possible Advantages

Marquet's report appears to indicate that the Livermore Antigone concept is not limited to mere beam propagation. Over the past decade there has been substantial research on how a laser could be utilized to accelerate charged particle beams in plasma channels. There have been even more sophisticated studies than Antigone—like those of Craig Olsen's ionization front accelerator at Sandia National Laboratories—on utilizing lasers with electron beams to generate more powerful ion beams in such plasma channels.

The point here is that a high-energy heavy ion beam can be more effective than electron beams in destroying targets. Could Antigone mean that the beam propagator is also the beam

Continued on page 61

Fred Rick/Los Alamos National Laboratory

To cut miniature parts, machinist Fidel Maestas uses special earphones to hear when his diamond cutting-tool touches the part. Then he bathes the piece with a cutting lubricant and uses an ultraprecision lathe. The inset compares two tiny machined parts to a number 8 sewing needle and thread. The parts, used as a target for a laser fusion experiment, have a sine wave inscribed on the left in a horizontal pattern and on the right in a vertical pattern.

Laser Beam Research Spins Off Precision Machining Technology

New ultraprecision machining techniques developed to meet the needs of the laser beam and nuclear research programs at the national laboratories are now ready for industrial development. As described by Los Alamos National Laboratory, laboratory "machinists are now working with miniatures so exquisitely small . . . they can only be examined under a microscope."

The ultraprecision machining technique is made possible by the combination of advanced machining methods, specialized computer programs, and a Hewlett-Packard laser measuring system.

The most immediate impact of this new technology is on the optics used in laser beam weapons. Ultraprecision machining provides a very economical means of obtaining the extreme precisions needed for the large, irregularly shaped mirrors used for both ground-based and space-based laser beam weapons. The polishing methods used now to obtain high-precision finishes for laser mirrors are very costly and become more so as the shapes of the mirrors become noncircular.

In some cases, once the desired shape mirror or lens is prepared with the new ultraprecision machining technique, it could be further improved with the old polishing technique. Optimal combinations of these various methods are now being researched. The main point, though, is that the new technology makes the production of large, precision mirrors and optics economical.

The essential ingredient for this new machining capability is the use of precision measurements made possible with coherent laser light. The same method is also being applied to the laser radar technology needed for detecting nuclear warheads in space. The measurement resolution achieved is 30 billionths of a meter—1 millionth of an inch—about 40 times smaller than the wavelength of the laser light utilized.

The greater resolution is attained by using the coherent nature of laser light to measure the phase differences in light-wave packets. Sophisticated computer programs are used to analyze the measurements of the phase changes induced by the interference of the object to be measured and the laser light. This same technique is also used to increase the resolution of ordinary microwave radars.

On the machining side, vibration, heat, and rates of cutting must be carefully controlled in order to attain the maximum precision made possible by the Hewlett-Packard laser measuring system. As Dick Rhorer, who heads up the Los Alamos project, put it: "The machinists play a major role. . . . Our machinists have had to develop specialized skills for this novel technology, and they approach their work with an extra measure of patience."

"While not every industry will feel they can afford the slightly greater cost of machining miniatures and smooth surfaces," Rhorer said, "in the long run the expense is absorbed by the higher and longer-lasting performance of the near faultless piece." This is especially true, he said, if precision alignment is needed, because the cost of adjusting fabricated parts often exceeds that of a machined piece.

Decision Point for Fusion, Space Programs

There is very little time left for the President Reagan to decide whether the United States will remain a leader in space technology and fusion. To ensure the continuation and growth of programs whose very existence is now in jeopardy, the President must take actions that counter those of his Malthusian "free enterprise" advisors.

For the past four years there have been contradictory policies coming from the Reagan administration on fusion energy, the space program, and nuclear power. Although the President has put forward the correct policy in these areas, it has been nullified by his advisors and appointed officials. For example, President Reagan has expressed a personal commitment for a stepped-up civilian space effort, centered on a permanently manned orbiting space station. On March 29 he appointed a National Space Commission to "devise an aggressive space agenda to carry America into the 21st century."

But the President has around him a financial mafia (known as "economic advisors") who would sooner shut down advanced energy research and space technology than support these developments as the way to get the economy moving foward again.

Keyworth's Fusion Shell Game

The fusion program is another case in point. Severe cutbacks in the program (with the exception of a small increase in small, high power density projects) have slowed down the rate of progress in fusion development—a lag that will hurt the pace of the Strategic Defense Initiative. Yet presidential science advisor George Keyworth has insisted that the fusion budget could be cut because international cooperation could take the place of a well-funded U.S. fusion effort for the next-step experiments.

"Wishful thinking about international cooperation" is the way Joseph Gavin of the Grumman Corporation characterized Keyworth's plan. Gavin heads up a Committee on International Cooperation in Magnetic Fusion Energy "to study and recommend a worthwhile course of action in fusion cooperation." The committee was established in September 1983 by the U.S. National Research Council.

Gavin evaluated the administration's proposal to spend less on fusion in testimony March 18 before the Energy Research and Development Subcommittee of the House Committee on Science and Technology. The Europeans "don't see the United States having a detailed future plan," Gavin reported. "People overseas see the U.S. program as having peaked out and losing momentum," he explained. "We have been an unreliable partner in the past. International cooperation will require a long-term U.S. commitment."

Gavin's comments were seconded by Dr. Tihiro Ohkawa, vice president of GA Technologies. Unless the U.S. fusion program stays at the frontier, no international cooperation is realistic, Ohkawa said. "After all," he stated, "who would want to cooperate with us if our capabilities were inferior to their own?

Yes or No on Space?

The situation with the space program is similar. President Reagan wants to see the space program grow into new capabilities. So did President Nixon after the triumph of the Apollo program. In 1969, Nixon set up a Space Task Group to plan the post-Apollo space program. Dr. Thomas O. Paine, the head of President Reagan's new National Space Commission, was then the head of NASA. The Task Group recommended a manned mission to Mars as a long-range goal and an increase in the NASA budget.

Before the Task Group's recommendations were even considered, however, the Office of the Budget slashed the NASA funding by $45 million, ending all plans for a space station, lunar base, and Mars mission.

The Office of Management and Budget, now under David Stockman, has done the same to President Reagan's 1984 space proposals. President Reagan mandated the development of a space station in January 1984. In a matter of months, David Stockman cut $50 million from the NASA request for the fiscal year 1986 space station budget. Unless the President takes on this sabotage, he will watch his plans for the future of the nation evaporate.

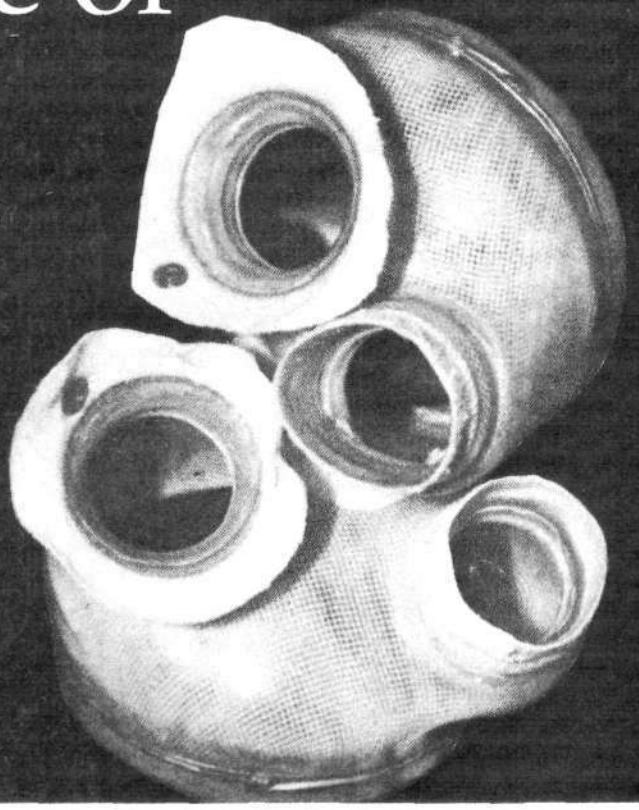
If he wants to save the nuclear industry, he will have to change the economic and credit policies that are pushing suppliers and electric utilities into bankruptcy. If he intends to build a strategic defense and ensure this nation an unlimited source of energy, he will have to stop the invention of all sorts of rationales for cutting the fusion budget and get on with the real development tasks.

—Marsha Freeman

Medical science is about to tap the proverbial fountain of youth. Current and immediately available technologies can eliminate killer diseases, retard the aging process, and extend the productive life span.

The Medicine of The Future Is Here Now

by John Grauerholz, M.D., and Wolfgang Lillge, M.D.



The artificial heart provides real hope for treatment of end-stage heart disease. Here, the Jarvik-7 artificial heart.

A revolution in the technology of diagnosis, treatment, and prevention of disease is under way. Recent advances in understanding the immune system, the development of the artificial heart and other life-saving technologies, and new breakthroughs in the use of directed energy beam (laser) processes have brought medical science to a point where man can now conquer many of the leading killer diseases and significantly extend the productive human life span. Ironically, man has reached the edge of this new era of ability to dominate nature just as the health infrastructure of the advanced sector is collapsing at an accelerating rate and starvation and disease threaten to decimate much of the developing sector. The world was never more in need of the medical knowledge and tools to reverse a situation of imminent biological holocaust. As we show, we have the medical knowledge and tools to do it.

Lasers in Medical Treatment

Research into lasers and other directed-energy technologies has brought us to the verge of fundamental breakthroughs in biology and chemistry that will dramatically transform medicine and industrial chemistry. Technologies now available and soon to come on line are but the tip of the iceberg of the most profound change since the introduction of the heat-powered engine that drove the industrial revolution. Already the use of lasers has greatly altered medical practice in many specialty areas, primarily as a surgical tool.The use of lasers in surgery is now widespread, and for some conditions lasers are the only available therapy. Loss of vision from diabetes, diabetic retinopathy, for example, was untreatable 10 years ago, but now lasers seal the hemorrhaging blood vessels that once led inevitably to blindness. Medical lasers generate heat in the tissues on which they are used and this heat is used to destroy the tissue—in the case of tumors—or to coagulate or "weld" the tissue, as in the treatment of retinal detachment in the eye. Because the laser energy can be precisely focused and varied in intensity, it is ideal for delicate eye and ear surgery.

Now a significant development is unfolding in the area of laser surgery of coronary artery disease, one of the leading causes of death and disability in the United States. A new laser, known as an excimer or excited dimer laser, eliminates the problems that make current medical lasers unsuitable for treatment of coronary artery disease. With oth-

er types of lasers, the heating effect in blood vessels increases the tendency for blood to clot at the treated site, which is precisely what one wishes to avoid in coronary arteries. The other problem is perforation of the delicate arteries by the laser energy.

The excimer laser avoids these problems, producing short, intense bursts of ultraviolet light that shatter the molecules of the atherosclerotic plaque without heating the surrounding tissue. The bursts of light create shock waves that break the chemical bonds of the plaque molecules and vaporize the plaque into carbon dioxide, hydrogen, and other fragments. Each burst cuts away microns (thousandths of a millimeter) of tissue with great precision, thus reducing the possibility of perforation. The pulses are extremely short, lasting from 10 to 100 billionths of a second.

The laser is incorporated into a 1.5-millimeter diameter catheter, containing three bendable glass fibers known as fiberoptic elements. One fiberoptic element carries the laser energy; another shines a light on the catheter tip; the third provides a view of the area in front of the catheter. The initial laser used in the experiments was developed by NASA at the Jet Propulsion Laboratory for remote atmospheric sensing. So far the technique has been tested in cadavers, and live animal studies are expected within a year.

The estimated cost of the perfected laser-fiberoptic device is $100,000. With it, a patient could have his coronary arteries cleaned out in a few minutes and might not even have to stay overnight in the hospital! When one considers that 170,000 patients underwent coronary artery bypass surgery in 1982 at an average cost per person of $20,000, this would represent a savings of at least $3 billion a year. More important, a great many patients who could not tolerate surgery because of the severity of their disease could be treated by this method and restored to productive activity.

A key factor in utilizing the laser as a surgical tool has been the development of fiber-optic technology. The ability of thin, flexible, fibers to transmit light and laser energy has resulted in a series of instruments, generally referred to as flexible endoscopes. These can be inserted into the body through natural openings or small incisions, and used to visualize and remove or destroy, small tumors and other lesions. As a result, polyps of the colon can be diagnosed and removed in one procedure, without the necessity of major abdominal surgery. Or lesions in the bronchial air passages can be directly visualized and biopsied, without having to open the chest. This avoids the complications, and expense, of major surgery and anesthesia, with their attendant problems of wound healing and general metabolic strain on the body itself.

On a more prosaic level, reports from a French group indicate that a carbon-dioxide laser beam could be the most effective method of treating tooth decay. Laser treatment of dental caries produces a chemical and physical barrier to acidic decay and the formation of a tough pulp scar.

Beam Defense Spinoffs in Diagnostics

Some of the most promising areas now being explored in laser technology involve rapid, highly specific, and sensitive diagnostic techniques that minimize time and potential risk to the patient. These developments are an outgrowth of research on the beam defense and fusion programs in the national laboratories.

One device now passing from the purely research phase into medical application is the flow cytometer, developed at Los Alamos National Laboratory in New Mexico. In this machine, cells or individual molecules are suspended in liquid and pass through a flow chamber at rates up to 20,000 cells a second. The cells are illuminated by lasers of different frequencies as they pass through the chamber, and the absorption or scattering of the laser light, or the fluorescence of molecules excited by the lasers, is measured.

In combination with another emerging technology, an instrument called an angular-scanning CIDS spectrometer, the flow cytometer can identify bacteria in *less than an hour.* CIDS stands for circular intensity differential scattering; the device measures the scattering of left and right polarized laser light by viruses and bacteria. The CIDS can identify viruses in a few minutes, instead of the 2 to 14 days currently required.

To get an idea of the potential of this new technology, consider the fact that clinical microbiology laboratories in the United States generate $30 million a week in the process of isolating and identifying microorganisms—viruses, bacteria, fungi, and protozoa—from patients suspected of, or known to be suffering from, an infectious disease. Because of the time required by current techniques, the results are generally not available until after treatment has already begun, or treatment may be delayed—with sometimes serious consequences—until the diagnosis can be established. With this technology, a precise diagnosis can be rapidly established, thus avoiding delay and possible mistreatment.

Another application of the flow cytometer is the detection and isolation of cancerous and precancerous cells. Alterations in cells can be identified rapidly and with a high degree of specificity, utilizing a technique called laser immunofluorescence, which detects antibodies bound to cell surface antigens. Antigens are generally protein molecules, sometimes combined with sugars, which form part of the membranes of cells. These antigens stimulate the immune system to produce proteins, called antibodies, which bind to them. A number of present diagnostic tests, known as radioimmunoassay, involve using antibodies labeled with radioactive isotopes or enzymes to bind to the surface antigens, which are then assayed for binding by measuring radioactivity or enzyme activity. These tests require multiple steps and the use of expensive radioisotopes. In contrast, the flow cytometer uses a photometer to measure the intrinsic fluorescence of antigen-antibody complexes with a sensitivity two orders of magnitude greater than the isotope technique. Also, the new technique requires only one step prior to running the specimen through the cytometer.

The flow cytometer can isolate individual cells in a miniscule, electrically charged drop of water and separate them from other cells electrically. Currently, Los Alamos scientists are working on the detection of single molecules by their fluorescence pattern after laser excitation, and subsequent isolation of these individual molecules in 1 picoliter, 1 billionth of a liter, of liquid.

Another use of the flow cytometer, with longer-range implications, is a project of Los Alamos National Laboratory

and Lawrence Livermore National Laboratory to stockpile a complete library of the human genetic code. The library would be a repository of complete genes and fragments of genes, the pieces of the genetic code that determine the characteristics of an organism. These fragments are separated in the flow cytometer and then genetic engineering is used to insert them into bacteria and produce quantities of the gene product. This library is three-quarters complete and will be finished in another six months.

Another development that promises to have a major impact on one of America's foremost health problems—heart disease—is a diagnostic tool enabling doctors to "see" inside a patient's arteries around the heart. This technique, the use of high flux, monochromatic X-rays produced by a synchrotron accelerator, grew out of research on high-energy particle accelerators.

The present method for visualizing the arteries of the heart is to cut into an artery, thread a catheter into the heart, and then inject dye into the coronary arteries. There are many complications associated with coronary angiography—as this technique is known—including possible heart attack and sudden death. By using the synchrotron X-rays and image enhancement techniques, the same information can be obtained with only a small injection in an arm vein. This would make coronary angiography feasible as a screening technique for asymptomatic patients who are at risk of coronary disease by family history or other factors. The first human studies of this technique are scheduled late this year at Stanford University.

Coronary artery disease often strikes middle-aged men in the prime of their productive lives. Screening by synchrotron angiography and treatment by fiberoptic lasers could result in prolonging millions of productive lives at relatively low cost, and the virtual elimination of one of the major killer diseases of our time. Even as a research technique, the ability to do repeated, nontraumatic, coronary artery angiography would enable scientists to determine if other methods of treating coronary atherosclerosis actually work.

X-ray Microscopy and Holography

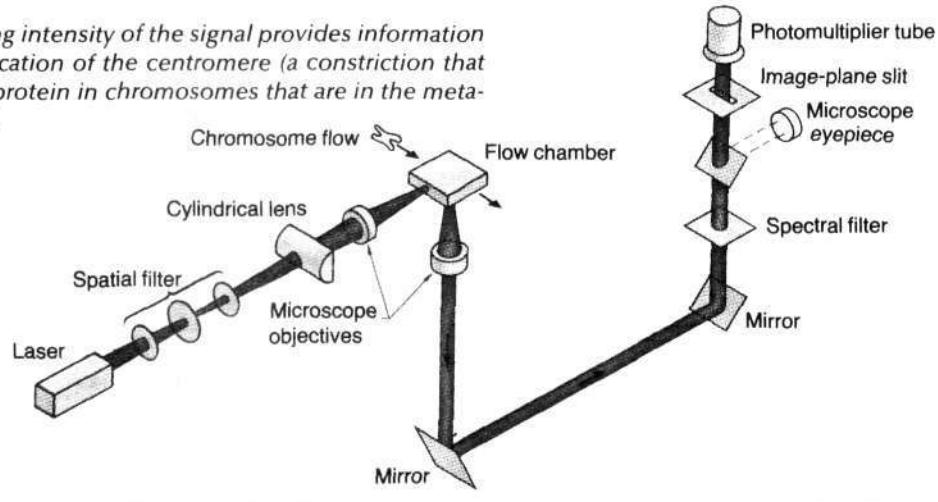
In recent years, significant progress has been made in imaging hydrated organic specimens with X-rays, and soon researchers expect to produce three-dimensional X-ray holograms of living matter with a resolution and contrast never before possible. This would overcome the essential disadvantage of today's electron microscopy, which images only dead matter. Important work on X-ray imaging was done at the State University of New York at Stony Brook, Brookhaven National Laboratory, the Los Alamos National Laboratory, as well as other research facilities in the United States and West Germany. Because soft X-rays are not significantly altered by the presence of air and water, dynamic experiments and analyses of living, viable biological samples are now possible, using X-ray radiation that lasts for several hours.

In fact, workable results in X-ray microscopy have already been achieved using a flash X-ray source, which is capable of producing an intense burst of soft X-rays lasting only 50 nanoseconds (50 millionths of a second). Further progress in terms of resolution and contrast is expected when the X-ray source can be tuned to the specific absorption edges of

Figure 1
SCHEMATIC OF THE SLIT SCAN FLOW CYTOMETER

A suspension of chromosomes stained with a DNA-specific fluorescent dye flows at 10 meters per second through a narrow tube past an intense blue laser light focused to a 1 to 2 picometer-wide ribbon. The laser light excites fluorescence from the illuminated region of each chromosome. The emitted fluorescence is focused by a microscope objective and separated by a spectral filter that does not transmit the scattered laser light. The fluorescent light illuminates a photomultiplier tube connected to a signal processor.

Analysis of the time-varying intensity of the signal provides information on DNA content and the location of the centromere (a constriction that joins the units of DNA and protein in chromosomes that are in the metaphase stage of cell division).



a particular biological element, generating images of cell structures containing a concentration of elements that are of specific interest for biological research.

Even more promising results could be obtained using X-ray laser holography—which produces three-dimensional "movie" images—to study cell structures. Experiments at Lawrence Livermore and Brookhaven show that this technology is now within reach. In summer and fall 1985, a new series of holographic experiments will be conducted, and the scientists involved hope to achieve a wavelength of 300 angstrom units—a resolution roughly corresponding to the size of a cell or cell organelles. To achieve greater magnification, it is necessary to develop coherent X-ray laser sources with still smaller wavelengths, 30 angstroms and less, a feat that seems to be only a question of time.

Imagine actually seeing three-dimensional processes as they occur in the microscopic and submicroscopic realm in real time! This will open up research areas in biology and medicine that were not hitherto accessible—especially concerning structures and changes of structures accompanying living processes—with space resolution down to a millionth of a meter and time resolution in billionths of seconds.

A hologram is created when a reference X-ray laser beam is correlated to a beam penetrating the specimen, where this latter beam is scattered and absorbed by the molecules. A "wave front reconstruction" is accomplished either by coherent illumination of the hologram or by an equivalent computer analysis.

Fred Rick/Los Alamos National Laboratory

Los Alamos scientist George Saunders demonstrating the flow cytometer, which can measure incredibly tiny amounts of substances precisely.

A 'New Window' into the Human Body

Nuclear Magnetic Resonance or NMR technology now gives medical science a fantastic diagnostic tool—the capacity to image the inside structure of the human body. But with some help from NASA, NMR is on the verge of becoming an even better diagnostic in a broad variety of fields, improving its quality by an order of magnitude. The key is a discovery two years ago that the computer that processes the data from NASA's Landsat satellite could also be used in the NMR imaging process. The potential for combining NASA-developed image processing technology with diagnostic NMR might advance medicine as far as the use of X-rays did some 50 years ago.

A team of radiologists and engineers from NASA's Kennedy Space Center, the University of Florida at Gainesville, and the Mallinckrodt Institute of Radiology at Washington University Medical Center in St. Louis has shown that the Landsat computer, which processes satellite images of the Earth, is able also to recognize specific body tissues and reproduce them as colored cross-sectional photographs of the head, chest, and abdomen. This much more precise view of the inside of the body will revolutionize diagnostics; doctors will be able to "see" pathological changes in tissues and organs that until now have been inaccessible or accessible only by invasive means.

The NMR machine consists of a large magnetic coil. When its strong magnetic field is imposed on a patient's body, it causes the proton of hydrogen atoms in water and other molecules to align themselves with the magnetic field lines. A second field of electromagnetic waves in the radio frequency is then beamed through the patient's body which, when turned off abruptly, leads to a characteristic oscillation of the hydrogen protons involved. This extremely weak emission of radio signals is registered and stored by the NMR machine on at least three different channels or layers.

The Landsat computer is ideally suited to interpret these kinds of data, since Landsat itself takes pictures of the Earth in several different spectral ranges that later are combined by the computer. In this way specific characteristics are enhanced, the constrast is sharpened, confusing details are removed, and so on. Some of the more spectacular achievements of the Landsat computer imaging have been its its detailed images of Jupiter, Saturn, and Mars, and its locating of mineral deposits and rich fishing grounds.

Even the initial results of NMR application "saved three years of effort that would have been needed using our own equipment," said Dr. Michael Vannier of the Mallinckrodt Institute, who initiated the joint work with NASA to see if computer processing techniques developed for satellite images could be applied to medical imagery. NASA specialists estimate that future computer processing might produce even three-dimensional views of a specific organ of the body by appropriately combining the thin slices of NMR imagery. This would mean that a three-dimensional reconstruction of any part of the body, viewed from any angle or even from the inside, could be reproduced on a computer screen!

Researching the applications of Landsat to NMR, which has been done mainly at the Mallinckrodt Institute in St. Louis, is still at the laboratory level of testing the most appropiate computer analyses of the NMR data, but very promising prospects exist for significant progress in the near future.

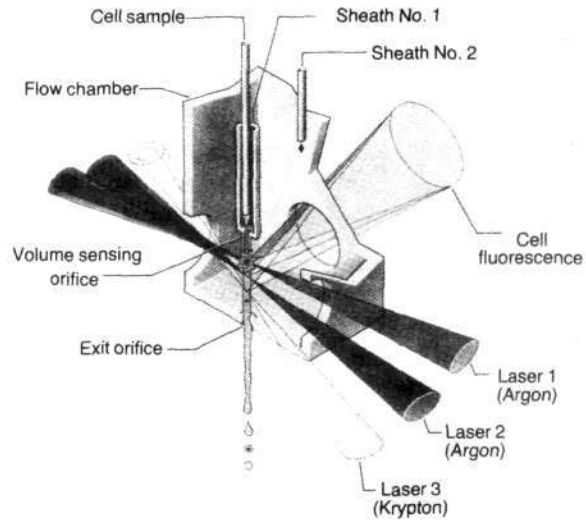


Figure 2
SCHEMATIC OF MULTILASER FLOW CYTOMETRY
Cutaway view of the flow chambers illustrating three-laser excitation with spatial positioning of the beams. On entering the chamber, the cells stained with fluorescent dyes and suspended in normal saline solution intersect a krypton laser beam and two argon laser beams. The fluorescence emitted by the cells is measured with sensors capable of detecting light in one, two, or three wavelength regions as selected by various filter combinations.

In fact, the real potential of NMR imaging is yet untouched; for, so far, only the resonance quality of hydrogen protons in tissue are being investigated. Actually, all atoms with an odd number of protons in their nucleus (atoms with a "spin" like hydrogen, carbon, fluorine, sodium, phosphorus and so on) could be used in NMR imaging, which is also called NMR spectroscopy. Already researchers have been able to detect NMR signals from phosphorus in sufficient intensity to produce images. Furthermore, it was possible to identify the relative concentration of phosphorus in compounds like phosphocreatine, adenosine triphosphat (ATP), and inorganic phosphate in human tissues or organs, which all play key roles in metabolic processes, especially energy transmission in cells.

This method could have tremendous significance. For example, NMR spectroscopy could provide insights into the functional and metabolic status of the brain, the heart, and other organs, or peripheral muscle tissue in various physiologic and pathologic states.

To advance this research, a more sophisticated computer facility is required—as is now potentially available with the Landsat equipment. In addition, basic progress is needed to build more efficient superconducting magnets with high field strengths and extremely high levels of field uniformity to reach adequate resolution of the signals emanating from the various phosphorus-containing compounds.

Dr. James Frazer at the Texas Medical Center in Houston has uncovered still another potential field of application for NMR, using the machine for both diagnostic and therapeutic means. Frazer found that tumor tissue absorbs and emits signals at frequencies and time distributions slightly different from normal tissue. Based on this finding, Frazer conducted experiments "tuning" the NMR machine exactly to the frequency of the tumor, and then rapidly increasing the power of the machine at this point. As a result, the tumor tissue heated up significantly, damaging or destroying the malign cells selectively without impairing the healthy tissue around the tumor. Although this method, too, is not yet introduced in clinical practice, it will get a definite boost when NMR spectroscopy is better understood, using more advanced computer systems like the Landsat facility to interpret the data involved.

The Artificial Heart and Related Technologies

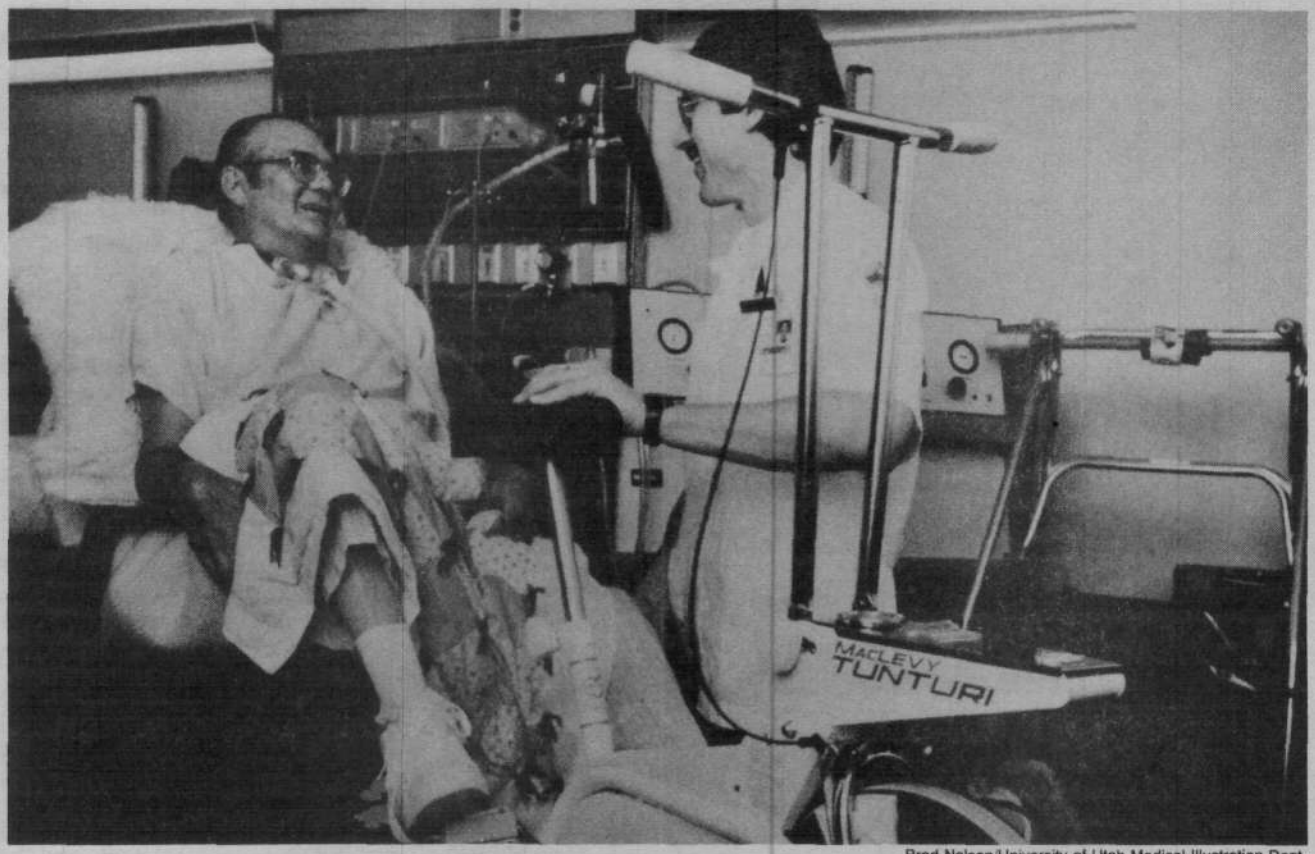
The artificial heart technology continues to progress, to the evident dismay of its critics. After five artificial heart implants, medical researchers have established that:

The artificial heart can extend the lives of people dying of heart disease. The findings of numerous animal experiments, that it is possible to survive and gain strength after a heart implant, are now confirmed in humans. Both Barney Clark and William Schroeder have lived longer than they would have without the implants, and Schroeder is now able to leave the hospital after recovering from a postoperative stroke, compounded by a bout of influenza. A third patient, Murray Haydon is also doing well.

The artificial heart has the ability to react to a patient's activity by increasing blood flow. Although the heart beat is set at a fixed rate, increased activity causes more blood to flow back to the heart, which then pumps out the increased volume with each beat. It is this ability to increase the quantity of blood ejected with each heartbeat, known as the stroke volume, that enables the heart to increase the volume of blood flow to the body or cardiac output without increasing the pulse rate, as would occur in a regular heart.

The portable power unit for the artificial heart, the Heimes driver system, is very efficient. This enables the patient to have a good deal of mobility. The portable drive is an 11-pound, shoulder-slung unit, which resembles a large camera case. It is powered by a rechargable nickel-cadmium battery and will enable the patient to leave his hospital room for for four to five hours at a time. The battery can be changed in seconds without interrupting operation of the unit, and an emergency battery will operate the unit for almost 12 hours if necessary. This is a very significant development for the future of the artificial heart as a treatment for heart disease and not just an interesting medical experiment. Ultimately the development of a self-contained unit driven by a plutonium-powered electric motor will enable the artificial heart to reach its potential as a treatment for severe heart disease.

According to Robert Jarvik, M.D., inventor of the Jarvik-7 heart, the major problem with the present mechanical heart is breakage of the pump diaphragms, which must flex 40 million times a year. His estimate is that the present



Brad Nelson/University of Utah Medical Illustration Dept.

The artificial heart eliminates reliance on the death of another person for a transplant. Here, Barney Clark, pioneer recipient of an artificial heart.

pump could last as long as five years, but would probably fail before then. Another problem with the present Jarvik-7 is size; the recipient's chest must be large enough to house the implant. The present heart consists of two chambers, each measuring 3.5 inches in height and 10.6 inches in circumference, weighing approximately 2/3 pound. The chambers are molded from polyurethane supported on an aluminum base and are held together as a unit by a Velcro patch. Several researchers are working on developing smaller models.

Other technological developments include the use of electronic stimulators to relieve pain and spasm in patients who have suffered various forms of nerve damage. This has recently been extended to a system that enables former paraplegics to walk again. Artificial ears, known as cochlea implants, could help up to 200,000 of America's 2 million deaf people. Artificial hips, arms, and hands are currently in use and being improved constantly, while artificial kidneys are becoming cheaper and more compact.

The artificial heart provides the only realistic hope for a treatment for end-stage heart disease that does not rely on the death of another person and that avoids the problems of graft rejection. Modern transplantation surgery has saved lives and made important contributions to the understanding of basic immunology. However, the use of donations from cadavers has opened up the Pandora's box of brain death and criteria for termination of treatment, and this has served as a wedge for the reintroduction of Nazi euthanasia policies into medical practice.

Advances in Understanding the Immune System

Acquired Immune Deficiency Syndrome, known as AIDS, is exemplary of how a pressing problem can stimulate the development of knowledge that transcends the problem itself. AIDS, a product of the cultural degradation of civilization that primarily affects promiscuous male homosexuals and intravenous drug abusers, has triggered fundamental advances in our understanding of the immune system. AIDS research, combined with other breakthroughs, made 1984 the year of the immune system.

Last April, scientists from the United States and France announced the isolation of a virus that selectively destroys T-cells, one of two primary types of immune cells, as the causative organism of AIDS. Since then a technique for growing the virus in quantity has been developed and a blood test for exposure to the virus is now being used for screening tests on patients and donated blood. This will ultimately lead to production of an effective vaccine against the dreaded disease.

In addition to susceptibility to unusual infections and rare cancers, an unusual debilitating dementia occurs frequently in adults and children with AIDS. This dementia, or encephalopathy (disease of the brain), usually begins with impaired concentration and mild memory loss and progresses to severe loss of all cognitive functions. Victims also may develop spasticity, staggering gait, and loss of leg function. These symptoms, believed to occur in many, if not most AIDS patients, progress over a period of weeks to months.

Recently (*Science*, Jan. 11, 1985), researchers reported finding evidence of the HTLV-III virus, believed to be the cause of AIDS, in the brain tissue of patients with AIDS and encephalopathy. This indicates that the virus itself, and not a secondary virus, parasite, or fungus, is responsible for the brain damage; it also indicates that there are similarities between the surface membranes of T-lymphocytes and brain cells. It is known that T-lymphocytes and brain cells share receptors for thymus hormone, and the affinity of HTLV-III for brain cells and T-lymphocytes suggests that these cells share a receptor for the virus. This could shed important light on the communication of information between the immune system and the nervous system.

Delaying the Aging Process

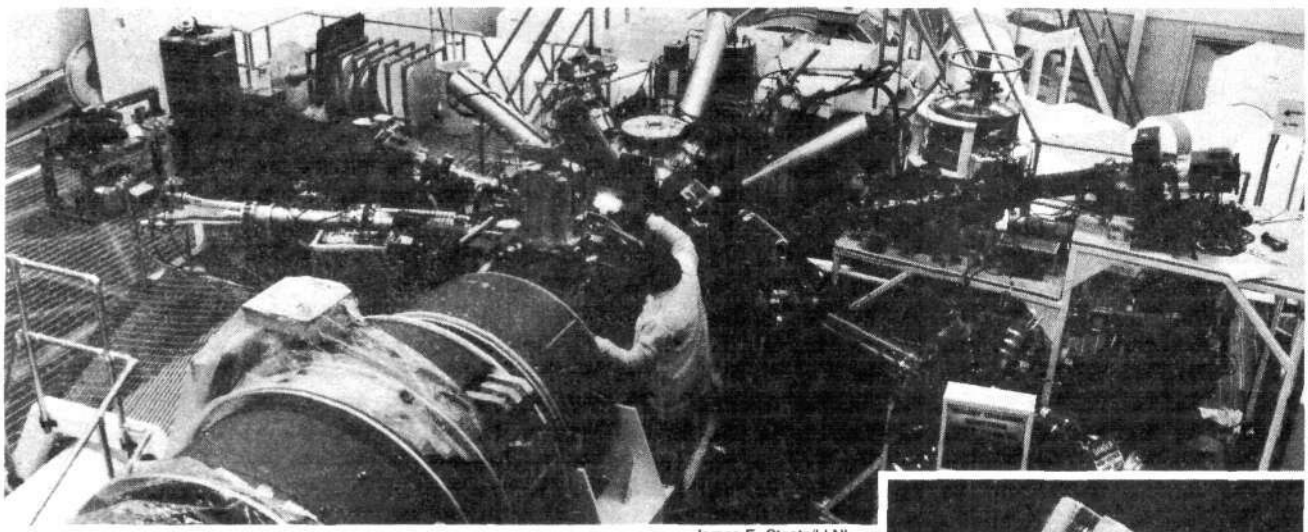
Immunology will be the spearhead of a breakthrough in the prevention and treatment of diseases of aging. A great many of the diseases and disabilities that occur in aging individuals are correlated with a decrease in function of the immune system. Immunologic changes in aging are manifest in two ways: One is a decreasing ability to respond to foreign antigens, including transformed (malignant) cells that have become essentially foreign to the body in which they arise. The second is an increase in antibodies produced against the self (auto-antibodies). Thus total antibody production is relatively unimpaired in older animals, but a significant portion of the antibodies produced are ineffective or harmful.

Many aging changes such as atrophy and shrinkage of lymph glands, fibrosis, renal atrophy, immune complex formation, weight loss, arteriosclerosis, changes in skin and hair, thymic atrophy, amyloidosis, decreased responsiveness to antigens, positive tests for autoantibodies, disturbances in T and B cell collaboration, increased numbers of suppressor cells, and activation of latent viruses are characteristic of autoimmune diseases. These changes occur mainly in the T-Cell (thymus-dependent) system, which is responsible for cell-mediated immunity and also plays a key role in activating the B-cell system, which is responsible for antibody production. The loss of T-cell function follows the age-associated shrinkage of the thymus gland, a plump, pink piece of tissue located at the junction of the neck and chest, which reaches its maximum size in late adolescence and shrinks almost to nothing by the mid to late 40s.

The key role of the thymus-dependent system in these changes has spurred scientists like Allan Goldstein of George Washington Medical School to examine the role of thymus hormones—for example, thymosin—in preventing or reversing these aging changes. Studies in animals and in human cells in laboratory cultures have repeatedly demonstrated reversal of age-associated changes in the immune system in response to administration of thymus hormones.

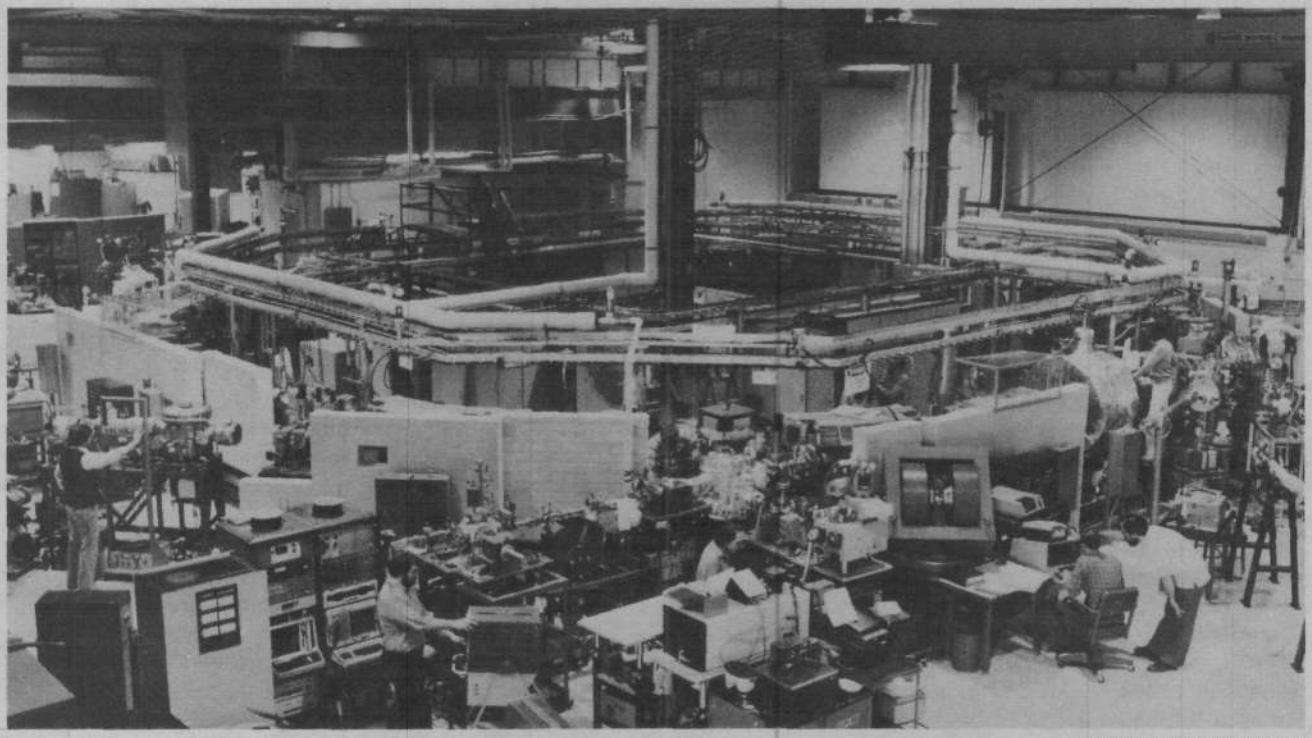
The first clinical trials of thymosin in the elderly will be conducted at the University of Vermont School of Medicine. This will test the ability of thymosin to boost the response to influenza vaccination. Influenza is still a major cause of death in the elderly, because the depression of immunity in these patients prevents them from making effective antibodies in response to vaccination.

It has been known for a number of years that the epithelial cells of the thymus have receptors for acetylcholine, a chemical responsible for transmission of nerve impulses



James E. Stoots/LLNL

The X-ray laser, a spinoff of the beam defense program, will make possible three-dimensional moving pictures (holograms) of biological activity at the atomic level of the cell. Shown here (above) is the target chamber of the two-beam Novette laser at Lawrence Livermore, which successfully produced soft X-ray lasers with a wavelength of 155 angstroms from the hot vaporized gases of selenium and yttrium. This is the shortest wavelength at which significant amplification has ever been observed in a laboratory. Inset is the metal foil held in a postage-stamp-sized target used in the Lawrence Livermore experiments. A 2,000 joule pulse of green light from each of the arms was directed onto the target to produce the X-rays.



Brookhaven National Laboratory

The ultraviolet storage ring of the National Synchrotron Light Source at Brookhaven National Laboratory. The Synchrotron's high flux, monochromatic X-rays will enable doctors to "see" inside a patient's arteries, thus greatly simplifying screening for heart disease.

from one nerve cell to another. Karen Bulloch of the State University of New York at Stony Brook has found that the autonomic nervous system sends nerve fibers to the thymus gland in a very specific pattern, which is similar in mice and men as well as chickens and lizards. The nerve effect on thymus epithelial cells, which secrete the hormone thymosin, is probably responsible for the development of the the T-cells, or thymus-dependent lymphocytes. In mice with deficient T-cell function, the nerve pattern of the thymus is abnormally sparse.

Other researchers have demonstrated that the spleen, lymph nodes, and bone marrow, as well as the thymus, have specific patterns of nerve fibers. These organs are also important parts of the immune system. The nerve fibers in these organs end in areas that are rich in T-cells and avoid areas rich in B-cells, which are antibody-forming cells derived from from the intestinal lymph glands.

The T-cells themselves have been shown to have two sets of receptors for neurotransmitters, the chemicals responsible for transmission of impulses from nerve to nerve. One set is for acetylcholine, and the other for norepinephrine (adrenaline).

On the other hand, there is now evidence that the immune system can influence the nervous system, including the brain. Studies by Hugo Besedovsky at the Swiss Research Institute show that immune responses alter the rate of firing of neurons (nerve cells), and Besedovsky has hypothesized that the immune system informs the brain about invading foreign antigens.

The suggestion has been made that soluble chemicals released by the activated immune cells cause these changes in neuronal firing. These include interferon and the interleukins, which also regulate immune cell function. This has led Allan Goldstein and Nicholas Hall of the George Washington University School of Medicine to suggest the name "immunotransmitter" for these substances, which are also known as biological response modifiers.

The search for a cure for AIDS has given additional impetus to the study of these biological response modifiers, especially those produced by the white blood cells and called lymphokines. One of the most promising of these is a substance known as interleukin-2, or human T-cell growth factor.

Interleukin-2 is a critical factor for growth of T-cells and augmentation of T-cell function. It is especially effective in stimulating production of specific cytotoxic (cell destroying) T-lymphocytes and other cells, known as natural killer cells. These cells form the body's natural line of defense against cancer cells, which arise all the time, but are spotted and destroyed by a healthy immune system. Several studies in animals have shown protection against tumor growth, and regression or control of established tumors, with Interleukin-2 treatment. Interleukin-2 has the potential to reverse deficits in T-cell function caused both by cancer itself and as a side effect of chemotherapy.

A focus on strengthening the immune system is a much more realistic approach to cancer prevention than the endless search for carcinogens. This is especially the case since some studies with the flow cytometer indicate there is a certain spontaneous rate of malignant transformation in cell cultures, even in the absence of carcinogens—a fact that casts doubt on a great deal of carcinogen research.

Because of this, there has been intense interest in producing large quantities of this substance for use in clinical trials. Since Interleukin-2 is a polypeptide (a chain of amino acids), one approach has been to produce it by genetic engineering. Although this has produced pharmacologic amounts of the amino acid chain, it does not add certain sugars that are also present on the naturally occurring molecule. A more promising approach has recently been developed by a company with the singularly appropriate name of Interleukin-2, Inc., which has developed and patented a process for producing human interleukin, with the appropriate sugars, from normal human blood cells. This product, which is actually a "cocktail" of a number of human lymphokines, was recently tested in phase 1 trials on cancer patients at St. Thomas hospital in London and has proven nontoxic and clinically effective in reducing the size of tumors. Phase 2 trials are now under way to evaluate therapeutic response in patients with cancer and AIDS.

Thymosin, like interleukin-2, is a biological response modifier and shows promise in treatment of immune deficiency dieases, cancer, arthritis, multiple sclerosis, and allergies. Allan Goldstein characterized the enormous potential of immunological therapy in his testimony at the U.S. Senate hearings on longevity and the lifestyle of older Americans held before the Aging Subcommittee of the Labor and Human Resources Committee, Sept. 27, 1984.:

> Indeed, the decade of the '80s, I believe, is ushering in a new age which should properly be called the 'Age of Immunopharmacology.' Through the thymosins, monoclonal antibodies, and other biological response modifiers, we are beginning to learn how to manipulate and harness the energy of the body's immune system in the same way that we have learned to harness the energy of the atom. Almost certainly, this information will translate itself into the conquest of many diseases which are thought today to be 'incurable.'

As a result of this fundamental research on cell function and reproduction and the elucidation of the workings of the immune system, biotechnology is the growth industry of the 1980s. Techniques have been developed that previously were only wishful thinking. Today scientists can insert genes for the production of animal proteins into bacteria, which then produce the proteins in large quantities. They can fuse cancer cells and normal antibody-producing cells to make a "hybridoma" cell, which then produces multiple copies of a single antibody, the so-called monoclonal antibodies. These technologies, initially expensive to develop, actually hold the promise of ultimately producing relatively inexpensive treatments and cures for conditions ranging from cancer and infectious diseases to the universal process of aging.

Vaccine Breakthroughs

One of the earliest—and still one of the most effective—methods of immune therapy is vaccination, which derives its name from the virus *Vaccinia*. This virus, which causes cowpox, was used by William Jenner to inoculate against smallpox and has been responsible for the total eradication of this once dreaded disease. Scientists at the New York State Health Department have developed a technique for genetically altering this virus to express up to eight different antigens, thus enabling vaccination against eight different diseases with a single injection.

Other breakthroughs in vaccine development include:

A vaccine for chickenpox, which infects 2 to 3 million children a year and results in 60 to 100 deaths has been developed.

A vaccine against hemophilus influenzae, the greatest cause of childhood infections, including pneumonia and meningitis, has been developed and proven effective in infants as young as 18 months. Inoculation of all eligible children could prevent 60 percent of these infections, which are potentially life threatening.

An inexpensive vaccine against hepatitis B has been developed from a synthetic protein. This disease affects about a million people in the United States and 250 to 300 million people worldwide, primarily in the developing sector where it is believed to be the cause of hundreds of thousands of cases of primary liver cancer. In a related development, French and American scientists have developed a quick, inexpensive test for primary liver cancer, utilizing monoclonal antibodies—chemicals that attach to specific target chemicals in the body.

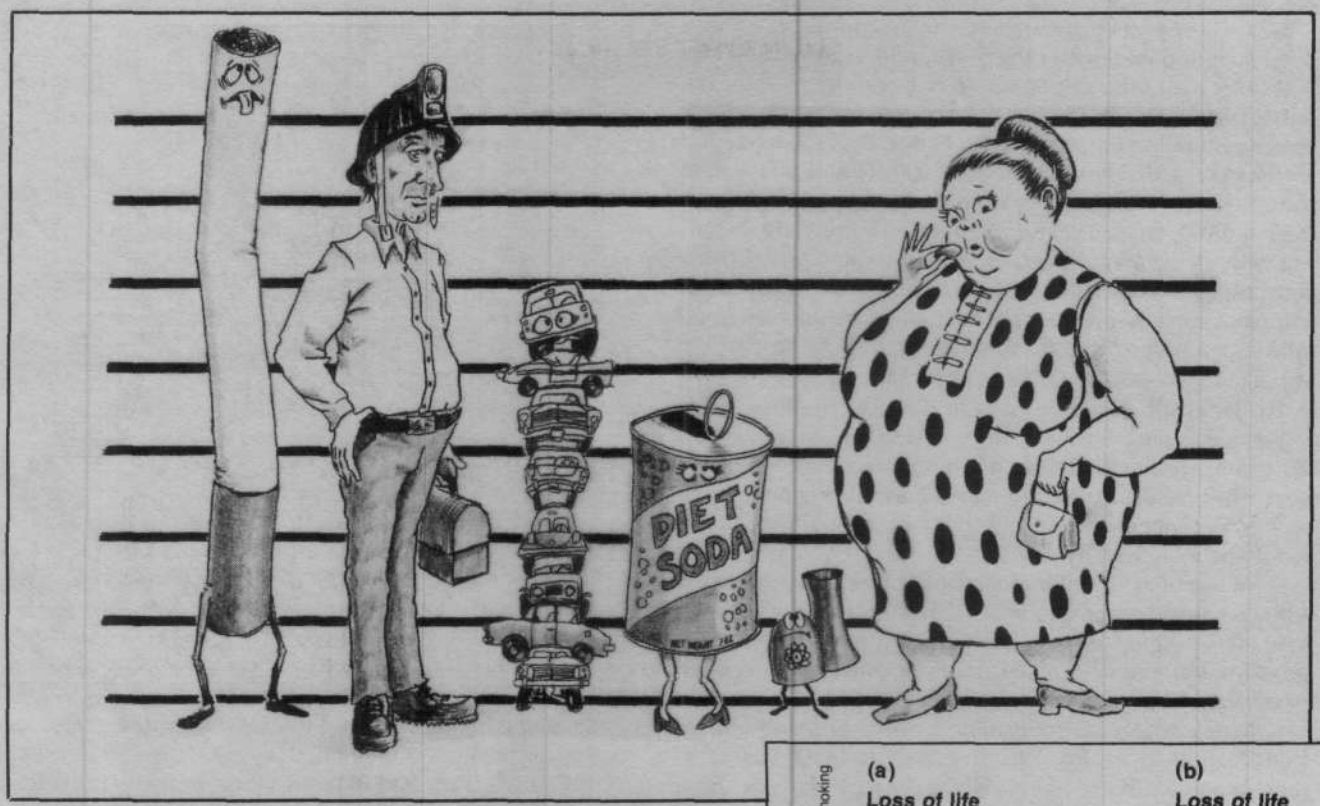
A new polio vaccine made from killed viruses promises to eliminate the last traces of polio from the U.S. in the next two years. In addition, scientists are developing a polio vaccine that can be administered by inhalation and mass produced for about 10 cents a dose.

One of the major breakthroughs has occurred in the long effort to develop a vaccine against the most serious form of malaria. Scientists have reproduced the genetic material that codes for a protein on the malaria parasite, thus stimulating the body to produce antibodies against the parasite. This genetic material can be inserted into bacteria, which will then produce the proteins in large quantities

We are thus in the paradoxical position of being able to significantly reduce and possibly eliminate major killer diseases like cancer and heart disease and to extend the productive human life span, at a point when we face the greatest ecological holocaust in human history. We are witnessing the onset of a series of epidemics which, unchecked, will rapidly depopulate Africa in the immediate future, and then strike Asia, Ibero-America, Europe, and North America. If this is allowed to occur, average life expectancy in the United States will drop to 50 years or less within the next generation, and what is left of the United States industrial economy will cease to exist.

The technologies discussed in this article, singly and in combination, would extend the average American life expectancy to over 100 years within the next decade and simultaneously raise Third World life expectancy and health to present Western levels. Which way the world goes—developing the technological fountain of youth or biological holocaust—is a political question.

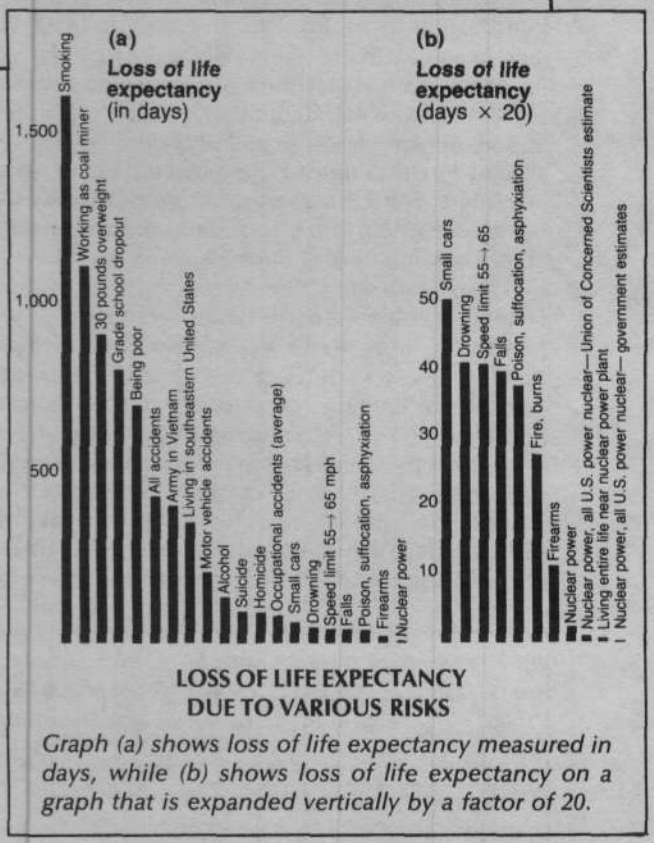
John Grauerholz, M.D., a forensic pathologist, and Wolfgang Lillge, M.D., a general practitioner, are both on the staff of the Fusion Energy Foundation.



Perhaps the most real "risk" today is that the fear-mongering of the environmentalists and the media will succeed in making Americans incapable of reason.

Putting 'Risk' In Perspective

by Dr. Bernard L. Cohen



LOSS OF LIFE EXPECTANCY DUE TO VARIOUS RISKS

Graph (a) shows loss of life expectancy measured in days, while (b) shows loss of life expectancy on a graph that is expanded vertically by a factor of 20.

EDITOR'S NOTE

Since the Three Mile Island accident six years ago, the environmentalists and the media have flooded America with propaganda on the risks of nuclear energy in particular, and modern industrial society in general. Every technological advance is portrayed as somehow taking away the pristine healthfulness of a nonindustrial, bucolic society. As the Fusion Energy Foundation has documented, the opposite is true: The greatest risk to the world population lies in stopping technological progress. For example, the FEF calculated that 110 million people died in the past 15 years, simply because the United States did not develop nuclear power plants at the rate scheduled in the Atoms for Peace program. The increased efficiency of nuclear power would have created an enhanced economic growth rate, particularly in the developing sector, to enable these 110 million people to live instead of die. Today, the stakes are even higher; without increasing investment in advanced technologies, we risk the lives of many more millions.

The best way to understand the magnitude of a risk is to compare it with other risks, and a convenient way of doing this is to compare risks on the basis of the *loss of life expectancy* that they cause. Let us say that a man's remaining life expectancy at age 20 is 55 years, and he takes a risk that has 1 chance in 1,000 of being fatal within a short time. The loss of life expectancy caused by this risk is $55 \times 0.001 = 0.055$ year, or 20 days. Most risks, however, are with us to varying degrees at all ages, and their effects must be added up over a lifetime to obtain the total loss of life expectancy. What I discuss here are the results obtained with a computer program calculating the total loss of life expectancy from a full range of everyday "risks." [1,2]

To start with some the risks of disease: the loss of life expectancy caused by heart disease is 5.8 years; for cancer, 2.7 years; stroke, 1.4 years; pneumonia and influenza, 0.4 year. This means, for example, that if a pill were developed to cure all cancers, the average life span in the United States would be increased by 2.7 years.

A well-known voluntary risk some of us take is smoking tobacco. Some of the details are listed in Table 1, where the loss of life expectancy is given in years. Note that the risk goes up with the amount of smoking, and with the depth of inhalation.

One risk not usually considered is that of being unmarried. A single man, age 20, can expect to live 6 years less than average if he remains single. When I first saw these figures, I assumed that much of this is because sickly people are less likely to marry, but that is apparently not the most important factor because mortality rates are even higher at all ages for the widowed and divorced. Examples are given in Table 2. Note that men suffer more than women from being unmarried, and blacks suffer more than whites. But in all cases, the loss of life expectancy from being unmarried is several years.

Another common risk is being overweight. If you are 10 percent or more above the average for your height and build, each extra pound causes a loss of life expectancy of 30 days; for example, an extra 24 pounds reduces life expectancy by 2 years. Each extra 100 kilocalories of food intake, all other things being unchanged, gives a loss of life expectancy of 15 minutes. This is more dangerous than smoking an extra cigarette, which gives a loss of life expectancy of 10 minutes (disregarding the facts that one cigarette leads to another, while eating may reduce later food intake). One diet soft drink has a loss of life expectancy of 9 seconds, because of the risk of bladder cancer from saccharin. But for an overweight person, a nondiet soft drink's kilocalories has a loss of life expectancy 100 times larger.

The most widely recognized risks are those in fatal accidents; the loss of life expectancy from some of them are listed in Table 3. We note that males die in accidents twice as frequently as females, and this ratio also holds for motor vehicle accidents and for accidents to pedestrians. Note also the very small loss of life expectancy from the highly publicized reactor meltdown accident. The first figure given is from the Nuclear Regulatory Commission's Reactor Safety Study, and the second is from the antinuclear activist organization, the Union of Concerned Scientists.

There is wide variability in the risk of being killed in an occupational accident. Some data on this for various industries in the United States and Canada are given in Table 4.

"Please marry me, Wilma, I'll simply die without you!"

". . . A single man, age 20, can expect to live 6 years less than average if he remains single."

Table 1
LOSS OF LIFE EXPECTANCY FROM SMOKING

Condition	Loss of life expectancy (years) Cigarettes Male	Female	Cigar (Male only)	Pipe (Male only)
1-9 days	4.5	0.2		
20-39 days	6.8	3.5		
More than 40 days	8.6			
No inhalation	4.5	0.6	0	0
Deep inhalation	8.6	4.6	3.2	1.4
Began after age 30	2.0	1.1		
Began age 15-19	7.7	2.7		

Table 2
LOSS OF LIFE EXPECTANCY FROM REMAINING UNMARRIED

Status, age	Loss of life expectancy (years) White male	White female	Black male	Black female
Single, age 20	6.0	3.2	8.8	6.0
Single, age 55	3.2	1.9	3.5	4.1
Widowed, age 55	3.9	2.7	6.2	6.0
Divorced, age 55	6.2	2.5	6.0	4.0

Actually, lumping whole industries together hides a lot of the risks. Much more detailed data are available from Canada, and large variations within industries appear: For example, among miners, the loss of life expectancy for shaft sinkers is 600 days versus 65 days for those in shops and service; among utility workers, the loss of life expectancy for those who work on power lines is 820 days versus 58 days for mechanics and fitters; among foresters, the loss of life expectancy for log-fellers is 1,060 days versus 54 days for those who work in saw mills; and in construction, the loss of life expectancy is 1,560 days for demolition workers versus 38 days for plumbers and electricians.

But death in accidents is only the "tip of the iceberg" for occupational risks. Occupational disease takes a far larger toll. The differences from average life spans for those in various occupations in Britain are shown in Table 5, corrected for social class. Note that in some occupations life expectancy is more than a year longer than average, whereas in others it is 3 or more years shorter than average. Choice of an occupation can affect life expectancy by several years.

Similar data are shown for the United States in Table 6. These are by industries rather than by occupation and it is not corrected for social classs, but similar conclusions can be drawn from it. Note also that the risk caused by radiation to workers in the nuclear industry is relatively miniscule compared to other occupational risks.

Table 3
LOSS OF LIFE EXPECTANCY FROM ACCIDENTS

Accident type	Loss of Life Expectancy (days) Male	Both sexes	Female
All accidents	669		297
Motor vehicle	363		150
Pedestrian	49		24
Falls	49		52
Fire, burns	31		26
Drowning	49		11
Accidents in home		95	
Pedal cycle		5	
Firearms		11	
Poison		17	
Suffocation, asphyxiation		13	
Reactor meltdown (if all U.S. power is nuclear)		0.02(2)*	

*First figure is from Nuclear Regulatory Commission Reactor Safety Study. Figure in parentheses is from the Union of Concerned Scientists.

Table 4
LOSS OF LIFE EXPECTANCY FROM OCCUPATIONAL ACCIDENTS

Industry	Loss of life expectancy (days)
All U.S. workers	74
Trade	30
Manufacturing, service	45
Transportation, utilities	164
Construction	300
Mining, quarrying	330
Fishing (Canada)	400
Forestry (Canada)	540

Table 5
DIFFERENCE FROM AVERAGE LIFE EXPECTANCY FOR OCCUPATIONS IN BRITAIN
(Data corrected for social class)

Occupation	Difference from average
Postmen, packers	+580
Government officials	+500
University teachers	+500
Gardeners	+380
Inspectors (metal, electrical)	+380
Foundry, ceramic workers	−600
Brewers, printers, tailors	−870
Coal miners	−900
Pharmacists, nurses	−1,050
Shoemakers, watchmakers	−1,100
Fishermen	−1,270
Actors, musicians	−1,350
Steel erectors, riggers	−1,450
Ship workers	−2,800

Table 6
DIFFERENCE FROM AVERAGE LIFE EXPECTANCY IN U.S. INDUSTRIES
(Data *not* corrected for social class)

Industry	Difference from average (days)
Clothing manufacture	+760
Communication	+500
Post office	+480
Rubber, chemicals	+290
Trade	+250
Paper, printing	+80
Business	+80
Metals, machinery manufacturing	0
Oil, gas recovery	−140
Electric, gas utilities	−250
Construction, mining (not coal)	−500
Railroad	−660
Firemen, policemen	−1,100
Trucking	−1,170
Coal mining	−1,180
Power reactors (due to radiation)	−12

Table 7
LIFE EXPECTANCY IN VARIOUS AREAS OF CHICAGO CLASSIFIED BY SOCIOECONOMIC LEVEL

	1960		1930	
Income Level	Males	Females	Males	Females
Whites				
1 (lowest)	60.0	67.7	51.2	56.4
2	64.6	71.2	56.2	60.2
3	66.5	72.8	59.2	62.5
4	67.9	73.8	61.2	64.4
5	67.4	73.6	63.0	67.2
Suburban	69.0	74.6	—	—
Nonwhites				
1	56.7	62.5	38.9	42.5
2	59.9	65.1	40.7	45.4
3	65.1	68.1	47.6	51.7
Suburban	66.1	72.3	—	—

Table 8
LIFE EXPECTANCY (YEARS) IN VARIOUS REGIONS IN 1976

Scandinavia	74
Japan	73
Australia, N. Zealand	72
United Kingdom	72
U.S., Canada	71
Southern Europe	71
Eastern Europe	70
Soviet Union	70
Argentina, Chile	67
U.S. Blacks	66
Carribean	64
Mexico, Central America	62
East Asia (not including Japan)	62
Northern South America	60
World average	59
Southwest Asia	55
North Africa	52
Southeast Asia	51
Southern Africa	51
Middle South Asia	49
East Africa	44
Middle Africa	42
West Africa	41
Mali, Niger, Chad, Ethiopia, Upper Volta, Mauretania, Guinea, Angola	38

Most Dangerous Risks: Unemployment and Poverty

But the most dangerous occupational risk is that of being unemployed. According to a recent estimate, a 1 percent increase in unemployment in the United States for 1 year causes 37,000 extra deaths, including 500 from alcohol-related cirrhosis of the liver, 920 suicides, and 650 homicides.[3] The loss of life expectancy from 1 year of unemployment is about 1 year. In addition to the 37,000 deaths, there are 4,200 admissions to mental hospitals and 3,340 admissions to state prisons.

Another risk some people take is being poor. Data for various districts of Chicago classified by socioeconomic class are listed in Table 7. We see that well-to-do people live 7-10 years longer than poor people; that is, being poor in Chicago means a loss of life expectancy of 7-10 years.

Another study shows that men with professional, administrative, managerial, and technical jobs live 4 years longer than unskilled laborers, and corporation executives live 3 years longer than the former; similar results apply to their wives, which indicates that the problems are socioeconomic rather than due to on-the-job risks. The ratio of white male mortality rates between ages 20 and 64 for poor people to well-to-do people is 3.4 for accidents, 2.7 for influenza and pneumonia, 4.4 for tuberculosis, 1.3 for cancer, and 1.6 for suicide. A closely related statistic is that college-educated people live 4 years longer than those who drop out in grade school.[4]

Table 9
LOSS OF LIFE EXPECTANCY FOR U.S. PUBLIC FROM ENERGY GENERATION

Source	Loss of life expectancy (days)
Coal	
Air pollution	12.0
Transport accidents	1.0
Oil	
Air pollution	2.0
Fires	2.0
Gas	
Air pollution	0.2
Explosions	0.4
Fires	0.4
Asphyxiation	1.5
Hydroelectric	
Dam failures	0.2
Nuclear (if all U.S. power nuclear)	
Routine emissions	0.02
Reactor accidents	0.02 (2.0)*
Transport	0.01
Waste (eventually)	0.01
Total	20.0
Total if nuclear energy replaces coal	7.0 (9.0)*

*First figure is from Nuclear Regulatory Commission Reactor Safety Study. Figure in parentheses is from the Union of Concerned Scientists.

The situation is much less favorable in poor countries. As Table 8 shows, life expectancy in well-to-do countries is more than 70 years, whereas the world average is 59 years, and in poor countries the average is about 40 years.

Risks of Energy Generation

The loss of life expectancy from the risks of energy generation are listed in Table 9. The largest risk here is from air pollution, which is estimated to be killing 10,000 Americans each year. These are mostly elderly people, with the average victim losing only about 7 years of life expectancy; for the average American, this works out to be a loss of life expectancy of 12 days.

One obvious observation from Table 9 is that coal burning is much more harmful to human health than nuclear power. That is the unanimous conclusion of every scientific study of the question, including studies by the U.S. National Academy of Sciences, the American Medical Association, the United Kingdom Health and Safety Executive, government agencies in various countries and states, and so on.[5] Even the technical study by the antinuclear activist Union of Concerned Scientists agrees, although that point is never mentioned in their nontechnical literature. The president of the Union has conceded the point publicly, and even Ralph Nader has conceded it privately. There are no scientific studies that conclude that nuclear power is more dangerous than coal burning. In fact, I have for several years been publicly offering a $50 reward for information leading to discovery of such a study, but there have been no takers.

When all the risks of energy generation are added, they give a total loss of life expectancy of 20 days. If coal burning were replaced by nuclear power, this number would be more than cut in half, even if we accept the estimates by the antinuclear activists.

The 20 days loss of life expectancy from energy generation is modest in comparison with most of the other risks we have discussed. It also must be noted that energy generation contributes substantially to wealth and prosperity, and that wealth adds years to our life expectancy. This surely more than compensates the 20 days of loss of life expectancy from Table 9.

Table 10
LOSS OF LIFE EXPECTANCY FROM INDIVIDUAL ACTIONS

Action	Loss of life expectancy (minutes)
Smoking a cigarette	10.0
Calorie-rich desert (if overweight)	50.0
Crossing a street	0.4
Driving an extra mile	0.4
Diet soft drink	0.15
Seat belt unbuckled (10 miles)	1.5
1 millirem of radiation	1.2
Coast-to-coast airline flight	100.0
Skipping one PAP test	6,000
Buying a small car	7,000

"That will be three years, please."

"Each extra pound causes a loss of life expectancy of 30 days."

The Risks of Energy Conservation

Some people seem to believe that energy generation is so dangerous that energy conservation should be practiced to preserve our health. But conservation also has its risks. Using smaller cars, even if everyone did it, would give us a loss of life expectancy of 30 days. Tightening houses to reduce heat loss traps naturally radioactive radon gas inside, giving us a loss of life expectancy of 25 days. This makes conservation by far the most dangerous strategy from the standpoint of radiation exposure! Reduced lighting is often used as an energy conservation measure. If it causes 5 percent more falls, it gives a loss of life expectancy of 2 days. If it leads to 5 percent more murders, that gives a loss of life expectancy of 4 days. If energy conservation doubles bicycling, that gives a loss of life expectancy of 5 days. Comparing these estimates with those in Table 9 indicates that conservation is by far the most risky energy alternative.

Some of the risks discussed here are exhibited on a bar graph in the figure, page 37. Note the 20-fold expanded scale on the right side of that figure, which exhibits the risks of nuclear power in true perspective.

Many of the risks can be expressed as loss of life expectancy from individual actions. Some of these are listed in Table 10. Included there is the loss of life expectancy from exposure to 1 millirem of radiation, the average dose received by those living nearby in the Three Mile Island acci-

dent. We see that their risk is equal to that of three street crossings or of driving an extra three miles.

Table 11 shows the increased life expectancy from various measures recently instituted or under consideration. It is clear that we are doing rather well in this area in comparison with the highly publicized risks of energy generation in general and nuclear power in particular. Medical advances in curing cancer in any one month compensate for all the additional cancers that may be caused by radiation from the nuclear industry. Clearly, if we put more effort into cancer research and less into reducing radiation, our health would benefit.

Table 11
INCREASED LIFE EXPECTANCY FROM SAFETY MEASURES INSTITUTED OR UNDER CONSIDERATION

Measure	Increased *life expectancy* (days)
Service by mobile intensive care units (advanced ambulances)	110
Safety improvements in last 10 years	100
Air bags in cars	50
Speed limits 65→ 55 mph	40
Smoke alarms in home	10
Annual improvement in cancer cure rate	10

Risk Aversion

Now consider the question of how much our society is willing to spend to save a life. This is based on a study in which all costs are expressed in 1975 dollars.[6] It is *not* a study of the value of a human life, which is a moral, philosophical, ethical, and religious question. Rather, it is a matter of collecting observations and performing mathematical transformations on them, which is a straightforward application of scientific techniques.

To illustrate with an example, if males over age 55 were given fecal blood tests to detect cancer of the colon and rectum, the fraction in whom tumors would be found is estimated to be 3×10^{-3}, and an estimated 20 percent of these would be saved by the early detection. Thus a program of testing 10^6 men in this age range should include 3,000 victims, of whom 600 would be saved. A fecal blood test costs $3, and it is estimated that collecting and delivering a fecal sample involves about $3 worth of inconvenience, making the total cost $6 per test, or $6 million for the program. Hence an expenditure of $6 million for the program would save 600 lives, an average cost of $10,000 per life saved. Most men in this age range do not have these tests.

Table 12 presents a summary of various programs that could save lives by medical screening or treatment. It is clear that many options are available that would save lives in the price range around $50,000 each. Table 13 shows the cost per life saved in various approaches to improving automobile and highway safety. We see that there are several available highway safety measures that would save a life for each $50,000 spent, and several automobile safety options for which the cost per life saved is a few hundred thousand dollars.

A summary of these and other life-saving costs is presented in Table 14. The immunization program in Indonesia would save 300,000 lives at a cost of $36 million, an average of $120 per life saved. The figures for sulfur scrubbers and radium in drinking water are Environmental Protection Agency estimates given in defense of their programs. The estimates for emissions control in nuclear power plants are based on the Nuclear Regulatory Commission's "1,000/man/rem" rule. The defense high-level waste figure is based on a Department of Energy justification of their plans for disposal of radioactive waste from the Savannah River plant, and the item on civilian waste is from the Department of Energy program at West Valley, N.Y., where a billion dollars is being spent to remove waste that has virtually no chance of ever harming anyone if handled in a much cheaper way.

The figure for reactor safety is based on the fact that the Nuclear Regulatory Commission has tightened safety measures in nuclear plants, requiring additional labor and materials and greatly increasing construction times, so as to raise the cost of a nuclear plant four to five times, by about $1.6 billion, since 1973.[7] The commission estimate was that a plant completed in 1973 would eventually cause an average of 0.8 deaths. If these increased safety measures actually avert these 0.8 deaths, the cost per life saved is $1.6 $\times 10^9/0.8 = \$2$ billion per life saved.

The figures in Table 14 are most disconcerting. We are spending billions of dollars to save lives from radiation while this money could save thousands of times more lives if

The Unemployment Line

"A 1% increase in unemployment for 1 year causes 37,000 extra deaths."

Table 12
COST FOR MEDICAL SCREENING AND MEDICAL CARE OPTIONS NOT WIDELY PRACTICED

Item	Cost per life saved (1975 dollars)
Cervical cancer screening	$25,000
Breast cancer screening	80,000
Lung cancer screening	70,000
Colo-rectal cancer	
Fecal blood tests	10,000
Proctoscopic exams	30,000
Multiple screening	26,000
Hypertension control	75,000
Kidney dialysis	200,000
Mobile intensive care units in smaller towns	30,000

Table 13
COST OF PROGRAMS FOR IMPROVING AUTOMOBILE OR HIGHWAY SAFETY

Item	Cost per life saved (1975 dollars)
Automobile equipment required by 1966-70 regulations	$130,000
Steering column collapsible	100,000
Air bag (driver only)	320,000
Tire inspection	400,000
Rescue helicopters	65,000
Passive 3-point harness	250,000
Driver education	90,000
Construction and maintenance practice	20,000
Better signs	34,000
Guard rail improvement	34,000
Bridge rails, parapets	46,000
Wrong way entry avoidance	50,000
Impact-absorbing roadside devices	108,000
Breakaway sign, light posts	116,000
Median barrier improvements	228,000
Clear roadside recovery area	284,000

spent on medical or highway safety programs. Thousands of lives are being lost unnecessarily each year because of this irrationality.

The Bugaboo of Radiation-Caused Mutations

In addition to killing people with cancer, radiation can induce mutations in sex cells that lead to genetic disease in future generations. That risk must be put into perspective.[8]

First let me point out some common misconceptions. The wildest misconception put forward is that radiation from the nuclear industry can destroy the human race. This represents a gross misunderstanding of genetics. Radiation only causes mutations, and far more mutations also occur due to other causes, but the frequency of genetic disease does not increase. The reason is that bad mutations are bred out. The rate of breeding out is proportional to the number N or

$$-\frac{dN}{dt} = \lambda N$$

If new mutations are induced at a rate R, the problem is analogous to that of producing radioactive material, for which the well-known solution is

$$N = R/\lambda\,(1 - e^{-\lambda t}),$$

which approaches an equilibrium with $N = R/\lambda$. Thus a small increase in R results only in a proportional increase in N. A full nuclear power industry—all electricity generated by nuclear plants—would increase R by about 0.003 percent, so the frequency of genetic disease would increase by that amount.

Another unfortunately common misconception is that radiation from the nuclear industry can cause monsters to be born, such as children with two heads. When a sex cell is hit by a gamma ray, however, there is no possible way for it to "know" whether that gamma ray came from a natural radiation source or a reactor-produced source. Since mankind has always been exposed to natural radiation, no new type of genetic disease can be expected to occur from nuclear power.

The eventual genetic impacts of having all electricity in the United States nuclear (250 GWe) would be 20 cases of genetic disease per year caused by occupational exposure, 13 cases per year caused by routine releases, and 4 cases

Table 14
SUMMARY OF COSTS PER LIFE SAVED

Item	Cost per life saved (in 1975 dollars)
Immunization in Indonesia	$120
Food for India	5,000
Medical (from Table 12)	50,000
Highway safety (from Table 13)	50,000
Automobile safety (from Table 13)	200,000
Sulfur scrubbers on coal-burning plants	500,000
Radium in drinking water supplies	2,500,000
Nuclear industry	
Routine emissions control	8,000,000
Iodine emission control	100,000,000
Defense high-level waste	200,000,000
Civilian high-level waste	1,000,000,000

"No new type of genetic disease can be expected to occur from nuclear power."

per year caused by reactor accidents (460 cases per year, according to the Union of Concerned Scientists), for a total of 37 cases per year—an increase over the natural rate by 0.003 percent (0.04 percent according to the Union of Concerned Scientists). The risk of having a genetic disease to a future citizen would be 1.0×10^{-5} (the risk due to other sources is about 3 percent). The risk to the child of a present-day radiation worker is 1.6×10^{-4}. and the risk to the child of nonradiation workers in our generation is 1.6×10^{-7}.

Some perspective on these risks may be obtained by comparing them with other sources of genetic disease. One of these is delayed conception of children. The risk of chromosomal disorder, like Downs Syndrome, increases with the age of the mother, and the risk of new dominant mutations, like achondroplasia, increases with the age of the father. It turns out that the increase of genetic disease caused by having all-nuclear electric power is equal to that from delaying conception of all children by 2.6 days. The average parental age of conception typically changes by about 15 days each year, giving six times the genetic effects of having all power nuclear. Freezing sperm and/or embryos from young prospective parents to be used when they are ready to have children would be hundreds of times more effective in avoiding genetic disease than stopping nuclear power.

Pants Versus Plants: The Genetic Risk

Another practice that increases genetic risks is men wearing pants. This increases the temperature of the gonads by 3.3 degrees Celsius, which increases the rate of spontaneous mutations. The temperature response for mammals has not been measured, but if it is assumed to be the same as for drosophila—there is no obvious reason to expect it to be either higher or lower—the effect is such that the genetic effects of all-nuclear-generated electricity is equal to that of men wearing pants an extra 8 hours per year. One day each year of wearing kilts, or avoiding use of tight pants would more than compensate for the genetic impacts of nuclear power.

Research offers great promise for future reductions in genetic disease. It is commonly said that half of all genetic disease can be eventually eliminated. And there is much that can be done to reduce genetic disease today, using such methods as amniocentesis, pulse echo sonography, fetoscopy, and alpha fetoprotein quantification in amniotic fluid or maternal serum.

Our Beneficial Legacy

A damaging insinuation about genetic disease in respect to the nuclear industry is that we enjoy the benefits today, while future generations must pay the cost. Yet look at the the process of history—each generation lives longer, healthier, and more rewarding lives. The reason is that each generation hands down a legacy of benefits.

Our generation is no exception. We will provide our progeny with a huge fund of knowledge and understanding; a large system of roads, bridges, transport systems, and communication networks; a tremendous capital plant of buildings and machines, educational, political, economic, and social institutions; and, above all, a thriving science and technology enterprise. Surely our beneficial legacy will grossly outweigh our detrimental legacy.

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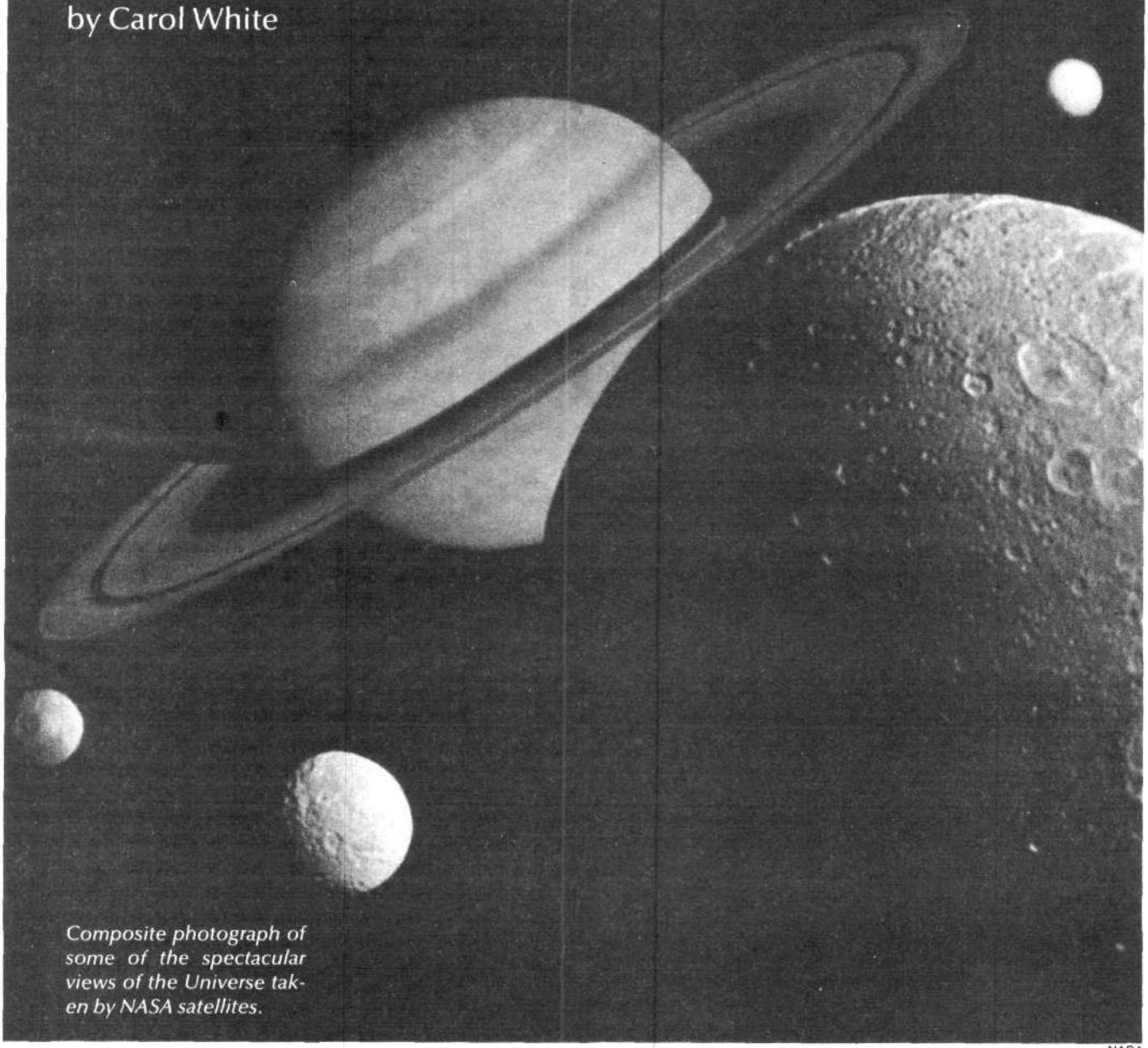
A new translation of Leibniz's essay on celestial motion and gravitation exposes the fraud of Isaac Newton.

The Universe Does Exist

Leibniz Refutes Newton on Dynamics

by Carol White



Composite photograph of some of the spectacular views of the Universe taken by NASA satellites.

NASA

In 1688, Gottfried Wilhelm Leibniz published a refutation of Isaac Newton's *Principia*. This work, "An Essay on the Causes of Celestial Motion," appeared in the *Acta Eruditorum* in reply to a lengthy review summarizing the *Principia*, which had been published in that Leipzig journal.[1] Even from the short account then available to him, it was clear to Leibniz that Newton's *Principia* was a slick attempt to undermine continental science, which was then flourishing under his leadership.

Leibniz had created a European-wide scientific network—chief among whom were Christian Huygens and the Bernoulli brothers. This grouping developed the foundations of analytic mechanics and wave theory by applying Leibniz's method of differential equations. In the process, they attracted and trained the best scientific minds in Europe. Essentially they were meeting the challenge put forth by Johannes Kepler some decades earlier to establish a new physics. To do this it had been necessary to reestablish the hegemony of the Platonic method in science, against the wreckage created by the Jesuit René Descartes and his school of scientific pretenders.

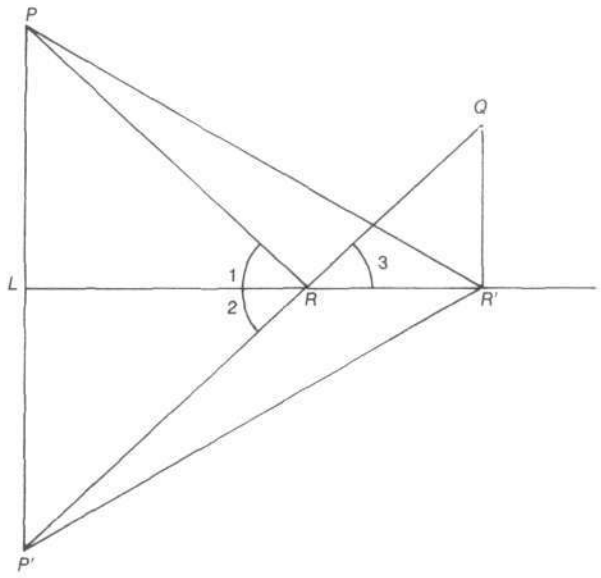


Figure 1
THE LEAST ACTION PRINCIPLE

The first known least action principle dates back to Heron of Alexander. Given line L *and two points,* P *and* Q *on the same side as* L, *for what point* R *on line* L *is* PR *and* RQ *the shortest path from* P *to* L *to* Q?

Let LR' act as for a mirror. Reflect P *into* L, *then* L *is the perpendicular bisector of* PP'. PR = P'R *and* PR' = P'R'. PR + RQ = *P'R* + RQ, *which equals* P'Q. PR' + R'Q = R'R' + R'Q. *But* P'R' + R'Q > P'Q *and* PR' + R'Q > PR + RQ. *Since angle 3 = angle 2, and angle 2 = angle 1, and angle 1 = angle 3, therefore,* R *occurs where the pathway makes equal angles with the mirror.*

How the Universe Operates

For Leibniz, as for Plato, God's universe is characterized by its tendency to perfect itself. Man has been placed here on Earth as its gardener, to carry out the command of Genesis: be fruitful and multiply. As Leibniz understood, the universe is inherently negentropic or self-developing. It is this overriding tendency that shapes all physical law.

Although the physical universe can be understood, to a certain approximation, in terms of a sequence of effective causes—like mechanical laws—the existence of the laws themselves, and the rules of their transformation, can only be understood in terms of this tendency toward the optimization of perfection that is embedded in the universe. To show this, Leibniz pointed to the governing role of least-action functions in determining what are normally considered to be the laws of physics. In the simplest case, this is shown by the laws of reflection and refraction in optics (Figure 1). These least-action functions—in modern terms the calculus of variations—were key in his development of mathematical physics.

At the start of the Renaissance, the significance of such principles was first recognized by Nicholas of Cusa in terms of the isoperimetric theorem of circular action, which states that for a given boundary measure, the circumference of a circle will enclose the largest area. Then why aren't the orbits of the planets circular? One might think that the creation of the universe would have followed this simple plan. However, the universe does not work on the principle of simplest circular action, because it is always transforming itself. Therefore, real physical processes develop by conical rather than circular action. For a cone, the least action is a logarithmic spiral. Such a spiral in one complete revolution is bounded by two circles whose axes can be projected to give the minimum and maximum radii of an ellipse (Figure 2). Thus, it is no surprise that Kepler discovered in his first law that the planetary orbits are elliptical.

Kepler's Second Law establishes that the radius of an orbiting planet, connecting it to the Sun, will sweep out equal areas of the gravitational field in equal amounts of time. If we look at how the rotational action of an orbiting planet accomplishes work, then at first sight it would appear that a maximum amount of work would be accomplished if the planet's orbit were perfectly circular rather than elliptical. But in fact, the elliptical orbit represents a crucial least-action function.

Not only did Cusa emphasize the importance of least-action functions, but he recognized the crucial feature of such functions. Such functions represent the efficiency of progress (in economic terms, for example, the cheapening of the cost of reproducing capital investment), but they also determine a unique pathway for action in the universe. A simple example to illustrate the point is the case of the gradient of a hill. Until the top is reached, for every path of ascent there is an opposite, descending path on which points of corresponding gradient can be marked off. The top, or maximum, is therefore unique. Indeed, it was this feature of uniqueness, first developed in Cusa's treatment of the

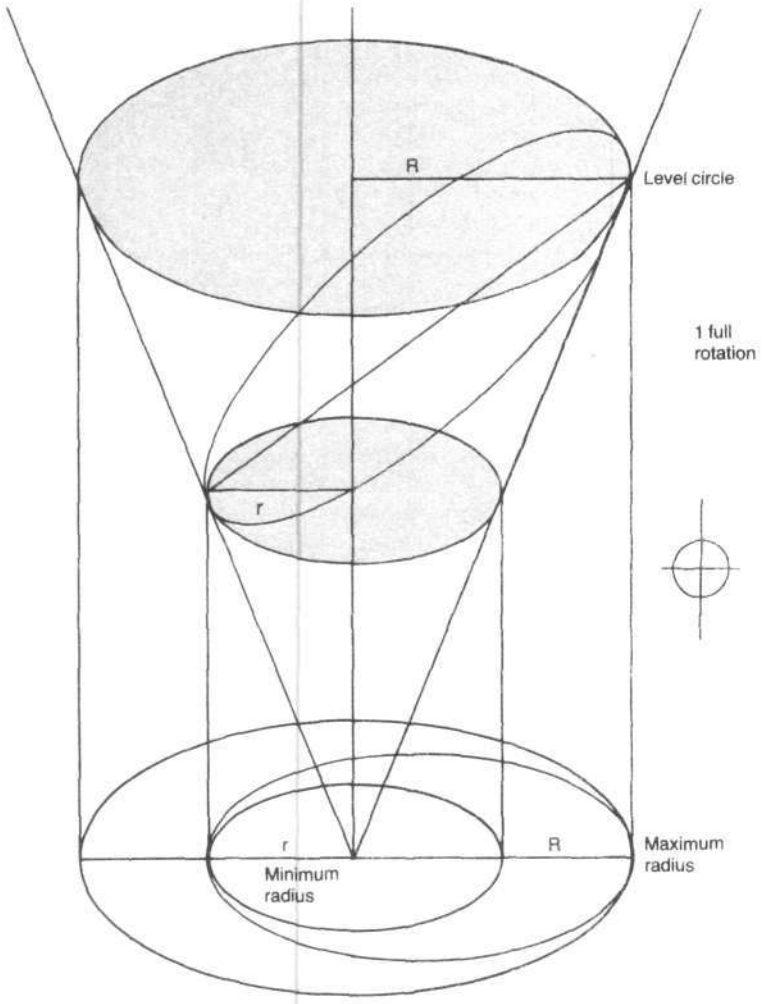


Figure 2
LEAST ACTION ON A CONE
Real physical processes develop by conical rather than circular action, and on a cone, the least action is a logarithmic spiral. In one complete revolution, the spiral is bounded by two level circles. The axes of these circles can be projected onto a plane to give the minimum and maximum radii of an ellipse.

isoperimetric function, that Leibniz later elaborated.

Nicholas of Cusa posed an essentially topological view of the universe, which sought physical law not in the metrical properties of events, but in the uniqueness of their occurrence. Thus he emphasized that from the point of view of topology, a maximum and a minimum are the same. For example, Cusa said that the circle and its centerpoint are identical, since the one can be shrunk into the other. Conversely, a point, in the sense that Euclid defines one, does not exist. In reality it is a *quantum of action*, that is, it has an area. The circumference of such a quantum of action bounds a singularity, or in Leibniz's terms, a *monad*. For Leibniz and for Nicholas of Cusa, epistemology and ontology were not separate.

In his "Essay on Dynamics," Leibniz essentially proposed a calculus of variations in its modern form:

> A weight which rises in virtue of its velocity will not attain a greater height, whether it rise perpendicularly or whether it rise obliquely on an inclined plane or even on a curve. It is true that the inclined rise requires more time to arrive at the same height, but it takes also a longer path and it makes more deviations. So in order to evaluate force by time it is necessary to consider in addition all paths and all deviations.

Leibniz's "Principle of Sufficient Reason" was merely another formulation of the fact that the universe operates according to a principle of least action, only he stated it in more clearly epistemological terms. Leibniz outlawed the goddess Chance as the explanation for the occurrence or nonoccurrence of an event. Thus, as he demonstrated in his correspondence with Isaac Newton (through the mediation of Clarke in the famous Leibniz-Clarke correspondence), space must be relative rather than absolute. Otherwise, by what criteria could we decide on the placement of an object here rather than there—this universe, rather than its mirror image? What is unique in space is relationship.

For Newton and Descartes, existence either was governed by chance, as an epiphenomenon of the arbitrary movement of matter, or was dependent upon the miraculous intervention of God. For Leibniz, existence was totally and uniquely lawful, from the microcosm to the macrocosm. As he expressed it, from all possible universes, God

chose that which would maximize the good. From that choice, existence and all action followed necessarily. Thus, the smallest quantum of action plays an absolutely necessary part in the continued development of the whole. Were he alive today, Leibniz would totally reject the Heisenberg-Bohr uncertainty principle by which these epistemological offspring of Descartes and Newton have reimposed the Gnostic goddess Chance upon science. The uncertainty principle assumes that action in the universe is only probabilistically knowable, since in Euclidean space the simultaneous direct measurement of the position and momentum of an atom is not precisely knowable. Leibniz recognized and identified all the ensuing evils of statistical mechanics and a probabilistic universe that follow from Newton's *Principia* as hereditary principles—and that now burden scientific practice.

In 1666, Leibniz submitted a thesis to the philosophy faculty at Leipzig titled "Dissertation on the Art of Combinations," which, ironically, used the method of combinatorial theory to make a statement directly counter to the presuppositions of present-day statistical mechanics. (Combinational theory tells you how many ways a collection of objects can be grouped; for example, out of 6 objects, one can get 15 different pairs.) For him, the universe was not probabalistic; it was not governed by a mean tendency. Rather, at every point, God governed his creation in order to optimize the amount of essence or active substance contained within the universe. This idea, in its final form, was expressed in Leibniz's *Monadology*. At any given point in its development, the universe is vectored to enhance its potentiality to create the greatest possible number of singularities (monads).

Were he alive today, Leibniz would be a vehement opponent of any willful limitation of population growth because he would recognize this as a violation of God's law. In his own time, he led the opposition to Isaac Newton's view that the universe is constantly poised on the brink of extinction. This Malthusian presumption was embedded in the axiomatic structure of Newton's physics. Since Newton believed that matter existed in the final analysis as perfectly hard, ball-like atoms, which moved through a void, he could not avoid the implication that without God's miraculous intervention, their continual collisions would cause a cessation of all motion.

The Cartesian World View

Before he could firmly establish effective principles for a new physics, Leibniz had to clear out the dead weight of Cartesianism from science. According to Descartes, matter was merely extended space and therefore lacked any innate capacity to act or accomplish work. Motion, therefore, was exogenous to matter. In his view, it was introduced into the universe at the moment of its creation, as an addition to matter or extended space, and was conserved as an invariant quantity. Not only did the physical universe operate like a machine, but even animals were considered to be mere machines. And man was a machine with an attached soul, connected through his pineal gland.

In contrast, Leibniz understood that the universe is alive. Each of its parts reflects the whole, albeit from a unique point of view. Man alone has the capability of understanding and willfully acting to transform the whole. Motion is merely a reflection of the process of transformation that characterizes all life. The task of science is not to describe motion, but to penetrate beneath its appearance in order to judge the actual, underlying process of development that is occurring.

Leibniz addressed this in the concluding section of his essay "On Dynamics":

> Motion is a transient thing which never exists strictly speaking, seeing that its parts are never all together. But it is force (which is the cause of motion) that truly exists, so in addition, apart from mass, shape, and change (which is motion) there is something else in corporeal nature: namely force.

This criticism, which applied equally well to Newton, was also elaborated in his "Critical Remarks Concerning Descartes's Principles":

> To be able to say that an object is moving, we will require, therefore, not only that it change its position with respect to others, but also that this body contain in itself the cause of change, a force, an action.

This force can be evaluated in some instances by changes in motion, but it is not the same as motion. Huygens in his work on the pendulum, was the first to identify the importance of mass × velocity squared as a measure of this force, but it was Leibniz who recognized its significance as an invariant measure. He termed it *vis viva*, or living force.

Descartes asserted that the amount of scalar momentum in the universe is invariant. This, of course, as Leibniz demonstrated, is ludicrously wrong. To make matters worse, Descartes asserted a series of laws that purported to describe the behavior of bodies upon impact. These were not only wrong, but fundamentally incoherent (Figure 3).

Descartes asserted that a body striking against a stronger one would rebound, losing nothing of its movement, but were it to hit less strong one, it would lose as much motion as it would communicate to the other. For Descartes, such incoherence was not problematic; irrationality was embedded in his point of view, because his criteria for moral judgment were fundamentally existential. This is exemplified by his famous one-liner: "I think, therefore I am," which he otherwise stated more precisely as: "I doubt, therefore I am." From this follows his expressed doubt about the reality of the existence of the universe apart from man. For this Jesuit, free will was expressed not as the right to create but the right to doubt!

Descartes's assumption that scalar momentum is conserved leads to the paradox of perpetual motion, which he apparently overlooked. Were the capacity to do work of a body of 1 pound traveling at a speed of 2 miles per hour, equivalent to that of a 2-pound body traveling at 1 mile per hour, a perpetual motion machine could be built. As Leibniz pointed out, a body weighing 1 pound and falling from a height of 16 feet is able to raise a body weighing 4 pounds

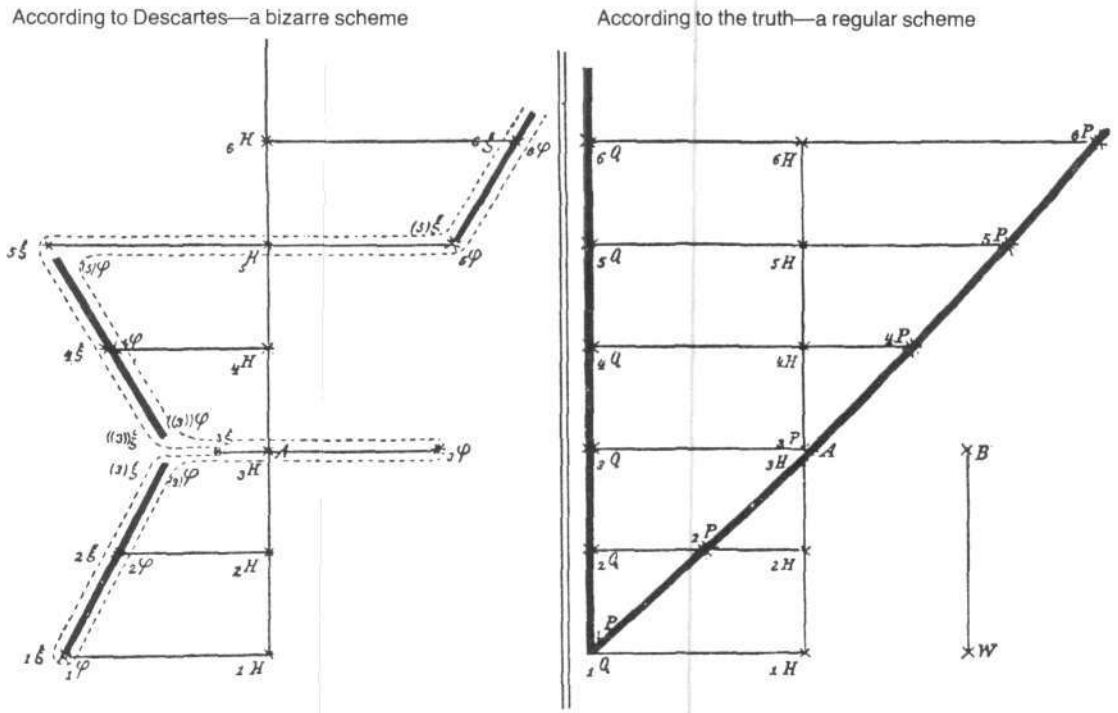


Figure 3
THE RULES OF MOVEMENT: DESCARTES VERSUS LEIBNIZ

This figure is reproduced from Leibniz's "Critical Remarks Concerning Descartes's Principles," under the title Representation of the Rules of Movement for the Case of the Collision of Equal Bodies.

Leibniz's subtitles summarize his evaluation of Descartes's rules. Leibniz notes in his legend, "Our diagram and the Cartesian agree on two cases only, H_1 and H_5 out of an infinite number. Our diagram obeys the Law of Continuity, the Cartesian shows discontinuity and leaps, in the line ΦΦ in Φ_3 and Φ_5, in the line XX in X_3 and X_5. The leap is marked by points to represent continuity. It is impossible to except from the coincidence of two continuous lines, ΦΦ and XX, a determinate number of points, e.g., two, so that all points Φ coincide with all the corresponding points X, except in two cases, namely Φ_1 with X_3, and Φ_5 with X_5. Yet this is what must happen in the Cartesian diagram."

to a height somewhat less than 4 feet. It being assumed that the quantity of motion is always conserved, the 4-pound body with 1 degree of velocity would be equivalent to the 1-pound body with 4 degrees of velocity, rather than 2 degrees of velocity—as is the case.

The *Principia* Fraud

Newton's *Principia*, as Leibniz immediately realized, was merely a new version of Cartesianism, although it pretended to be an attack upon it. It is important to realize that at the time it was published, Leibniz and his collaborators had already launched a full-scale attack against Cartesianism. The purpose of Newton's published disagreement with Descartes was to blunt the devastating attack that Leibniz and his grouping had already directed against Descartes.

The so-called discovery of a universal law of gravity by Newton, the ostensible subject of Book One of the *Principia*, was only a cover story for the real subject of the work, which is located in Book Two. In the second book, Newton claims to refute Descartes by showing that the planets cannot be made to circulate in the heavens by vortices. To substantiate this claim, Newton asserted a number of so-called axioms of fluid motion—most of which proved to be false, or merely plausible. His presumed disagreement with Descartes about the existence of a vacuum was by no means fundamental to either of their mechanistic world views. In fact, by controverting Descartes's incompetent physics, Newton was attempting a flanking attack on the work of Huygens and Leibniz, both of whom agreed with Descartes that there was no such thing as a complete vacuum.

Since, for him, matter and space were identical, Descartes necessarily denied the existence of a vacuum. Newton, on the other hand, accepted the existence of a vacuum in space. Yet, for him too, the universe was a dead place in which matter, in the form of hard balls, traveled aimlessly.

Science, of course, is never divorced from politics. While Leibniz devoted his life to building the republican networks that 100 years later won the American revolution, Newton and Descartes served the opposing side. Writing about Descartes's errors, Leibniz remarked, "If these misunder-

Isaac Newton: His Principia *was a slick attempt to undermine continental science.*

standings happen in an argument that is almost entirely pure mathematics, what must we not expect in ethics and metaphysics."

Newton was not a more challenging opponent than Descartes, in the realm of pure science; however, he was supported by some particularly evil political networks. In the context of the Hanoverian succession to the British throne, the contest between humanist and oligarchical networks was deadly. In fact, there is good reason to believe that Queen Anne was murdered because she was furthering the Leibnizian faction over the Duke of Marlborough, ancestor to the present-day Churchills.

Newton's patrons were the same enemies of the American revolution who later ran the British East India Company and masterminded the creation of the British empire. What was really being fought out, when Newton made the unbelievable claim that Leibniz had stolen the calculus from him, was the decision as to who would control the throne of Britain. Newton was merely providing a thin cover for the operation by the Venetian-controlled Churchills to keep Leibniz out of Britain and force his British collaborator, Johnathan Swift, into exile.

In 1686, when Isaac Newton published the *Principia* he was a relatively obscure Cambridge professor, even within Britain. The book was used to catapult him into prominence with a massive promotional campaign, which is still in full force to this day. There is a never-ending series of biographies of Newton that repeat the same canned stories. For example, over the last decade, there are three such that reshape the same material: Frank Manuel's *Portrait of Newton*, Richard S. Westfall's *Never at Rest*, and Gale E. Christianson's *In the Presence of the Creator.*[2] Newton is presented in these repetitious and lying accounts as the genius who founded modern mathematical physics. In fact, to take one of his alleged discoveries, Newton's theory of gravity was neither the cornerstone of modern physics nor even his own theory. This is made clear, despite the extravagant claims of his biographers, by reading between the lines of their own books.

Thirteen years before Newton's *Principia* appeared, Huygens had published a precise formula for calculating the centrifugal force of rotation—mass $\times$ velocity^2 divided by the radius of the circle of rotation, or MV^2/R. Once this was established, the centripetal force needed to maintain a body in orbit was essentially determined. To see this, merely substitute the ratio $2\pi R/T$, the time of orbit, in place of V in the formula, and multiply the numerator and denominator of the resulting fraction by R. Since, according to Kepler's Third Law, the time for a completed planetary orbit is proportional to the 3/2 power of its average distance from the Sun, this ratio can be restated as $K \times 1/R^2$, where $K = 4\pi^2 M\,(R^3/T^2)$.

Notwithstanding, Newton had not himself made this derivation, although in the 1660s he had discovered that the centrifugal force of the Sun was inversely proportional to its distance from the Earth. In 1679, Robert Hooke suggested to a surprised Newton that the inverse square law described a force law for gravity.

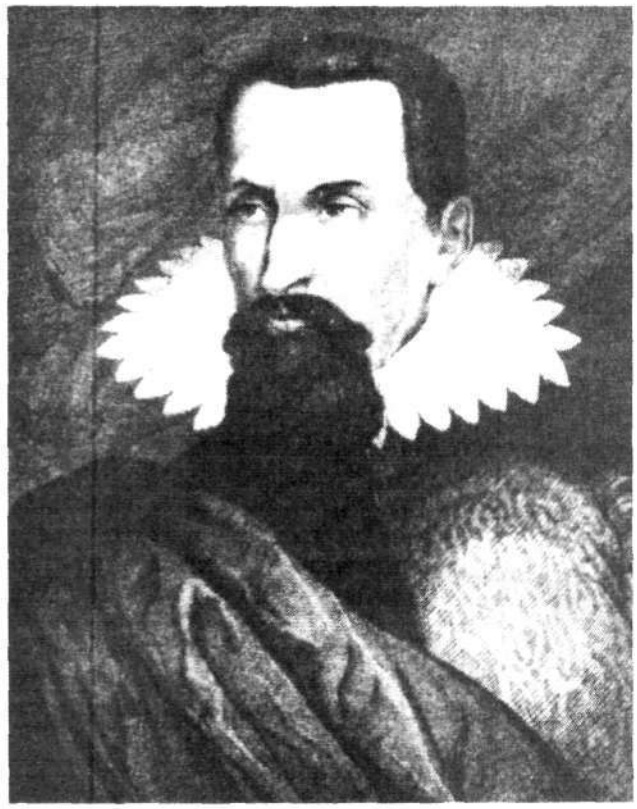
At that time Hooke also corrected a fundamental blunder by Newton, who thought that a body falling through the Earth to its center would follow a spiral rather than an elliptical orbit. So much for the independent genius of Newton! The *Principia*, as we know it today, is in fact based upon the second edition of that work, which was completely rewritten by Robert Coates, who was given the task of correcting the hundreds of errors that littered the pages of its first edition.

In 1960, C. Truesdale published a fascinating apologia for Newton, in the *Archive for the History of the Exact Sciences*, Volume 1. This article had the virtue of admitting Newton's bankruptcy as a scientist. As Truesdale correctly wrote:

> Except for certain simple important special problems, Newton gives no evidence of being able to set up differential equations of motions for mechanical systems. . . . To summarize: In Newton's *Principia* occur no motion for systems of more than two free mass points, or more than one constrained mass point. Newton's theories of fluid are largely false; and the spinning top and the bent spring lie altogether outside Newton's range.

Truesdale admits all this, but only because he founds his claim for Newton's importance upon Newton's supposedly unique ability to formulate the problems solved by his factional oppponents (not so identified by Truesdale), the Bernoullis and their successors like Euler and Lagrange. Of course Truesdale eliminates Leibniz from notice.

One need look no further than the *Principia* to document



Leibniz (left) and Kepler: Leibniz's European-wide scientific network fought to meet Kepler's challenge to establish a new physics based on the Platonic method in science.

that Newton could not have invented the calculus—which he accused Leibniz of plagiarizing from him—because he did not even understand it in 1686. His later claim that he failed to apply it in the written version of that work because he preferred to develop the *Principia* along more rigorous geometric lines, is ludicrous, for the *Principia* is anything but rigorous mathematically or scientifically. In it, Newton develops his mathematical arguments not through strict geometric constructions, but through appeal to the intuitive argument of differential triangles. This was, of course, the established method for differentiating and integrating before Leibniz invented the language of his calculus.

As Leibniz noted in an annotated copy of the *Principia* later found among his possessions, Newton made the consistent error of confusing first and second order differentials, so that he confused the initial impulse to motion (acceleration), which functions as an element of velocity, and the summation or integral of these elements, which varies as the square of the velocity and which Leibniz called *vis viva* (Proposition X, Problem V of book one).

Because Newton denied the existence of vortices in the heavens, he vacillated between denying the necessity to explain gravitational action at a distance and positing an occult explanation for it in terms of what he described as a spirit that diffused through space. Commentators try to identify Newton's more occult explanations of the action of gravity with modern field theory. The reader need only read the *Principia* and Newton's *Opticks* to disabuse himself of this.[3] Indeed, Newton's predilection for the occult has been amply documented by John Maynard Keynes, Manuel, et al.

In fact, upon his entry into Cambridge University under the patronage of Humphrey Babbage, Newton was immediately assimilated into occultist networks. The first book that he purchased was a treatise on astrology (it was this book that led him to study trigonometry). From the start, he was engaged in research in alchemy, and he was also deployed to research the gospels with a view to proving the legitimacy of the Syrian Bible as opposed to the New Testament. Even before this anti-Trinitarian became a member of the Royal Society and the Scottish Rite Masons, he was actively involved in the gnostic project of seeking to refute Christ's divinity.

The Three Laws

For Leibniz, it was irrefutably clear that gravitational action must be propagated from one body to another through some medium, or field. Such propagation would not occur as an emission of gravitational particles, but as what we would now call an electrohydrodynamic effect. The planetary orbits must operate by laws of fluid dynamics that demonstrate the necessary existence of vortices. How else, Leibniz asked, could the simple fact be explained that the planets all lie approximately on one plane and circulate in one direction.

Leibniz had an even more telling argument. Newton in the *Principia* had asserted his famous three laws, of which the first puts forward the principle of inertia. Objects once

in motion continue to propagate forward in space. Newton, of course, saw this as a mere tendency to resist activation. Furthermore, he made the banal mistake of attributing absolute rest to objects, just as he believed in the existence of absolute space and absolute time. Leibniz recognized this inertial impulse as identical to the force that causes a rotating circle to tend to expand or that causes a rotating body to fly out of orbit if it is not otherwise constrained.

Not only did Leibniz recognize the efficacy of a vector treatment of the interplay of forces, but it was precisely the appearance of such an inertial tendency that convinced him that a vacuum could not exist. Since rotational action is primary in the universe, if matter in a vacuum would tend to move in straight lines, then the vacuum could not exist. A medium must act that constrains the planets to rotate. Applying his least action principle, he wrote in a letter to Huygens on this subject: "For bodies take that position in which their motions are least interfered with. . . . The agitations of a confined fluid will turn into rotations."

For Leibniz, the change in living force or *vis viva* represented the capability of a body to do work or be worked upon. Newton, on the other hand, used the term force to describe a change in momentum; however he did not distinguish between instantaneous force and its integral over time. This is his second law. Only by dealing with the special cases of uniform forces and uniform velocities in the *Principia*, was Newton saved from extreme embarrassment.

Newton's third law, which was the independent basis for Leibniz's theory of dynamics, opened up the whole can of worms for him. This law asserts that for every action there is always opposed an equal reaction. However, it does not explain how such mutual interaction can be instantaneously propagated over enormous distances, without a medium of propagation being present. For Leibniz, Huygens, and the Bernoullis, of course, this law was key to their wave mechanics. In fact, Leibniz anticipated the work of de Broglie in posing the existence of matter waves.

It was upon the basis of the interaction of matter and the medium that Leibniz developed his theory of the elastic transmission of acoustic waves. In "On the Connection of Metaphysics and the Concept of Substance," he wrote:

> Active force . . . contains a certain action or entelechy, and is thus midway between the faculty of acting and the action itself, and involves a conatus [a velocity *differential*]. . . . I say that this power of acting inheres in all substance and that some action always arises from it, so that the corporeal substance itself does not any more than the spiritual substance, ever cease to act. . . . It will be apparent from our meditations that one created substance receives from another created substance, not the force of acting itself but only the limits and the determination of its own preexisting striving or power of actions.

Leibniz's Theory of Celestial Motion

Leibniz's essay putting forth his own theory of gravitation was really not so much an alternative theory as a spirited defense of Kepler's method. This is clear from his introduction, quoted here at length:

> It is well-known that the ancients, especially those who were determined to follow Aristotle and Ptolemy, had not yet understood the majesty of nature well enough. This at last became clear to our generation, and its predecessor, from whom it was learned that the hypothesis, which makes the planets revolved around the Sun, satisfies the phenomena beautifully. . . .
>
> This man [Kepler] accordingly discovered that each of the primary planets describes an elliptical orbit, in one of the foci of which would be the Sun, moved according to the law that the areas swept out by the radii drawn from the Sun to the planet, are always proportional to the times. The same man understood that the several planets of the same system have periodic times in a ratio of one-and-a-half times the square of their mean distances from the Sun. He would have been even more astonishingly successful if he had also known, (what Cassini especially noted), that the satellites of Jupiter and Saturn observe the same laws with respect to their primary planets as the planets do with respect to the Sun. . . .
>
> The first evidence of the physical use of the natural law of the motions is owed to him. Gravity is either derived from this, or at least made wonderfully clear by it. For rotated bodies do endeavor to pull away from a center along a tangent. Thus, if chaff or straw are floating on water, and the containing vessel is rotated, the water is made to move in a vortex, and it forces some straws toward the center, while the straws that are denser, and thus stronger than the water, are driven away from the center.
>
> He shows how this is done at two or more points in the "Epitomy of Astronomy," although he is still a little doubtful, and does not understand his strength, and is not conscious enough how much would follow, in both physics and particularly, in astronomy. Later this was especially useful to Descartes, even, if in his usual way, he kept the author a secret. Indeed I am often astounded at the fact that, as far as is known, Descartes did not even begin to report the ratios for the laws of the heavens that had been discovered by Kepler. He either did not know the joy of what had been discovered, or did not think they had been observed in nature with sufficient care, or could not reconcile them with his opinions. . . .
>
> I conclude that nothing else is left to explain the cause of the movements of the heavens than that which arises from the movement of an aether, or to speak astronomically, from fluid orbits which carry the planets. This way of thinking is most ancient, even if it has been neglected. Leucippus expressed it that way in employing the name "dinis" (vortex) to form a system. And we have heard how Kepler foreshadowed gravity with the movement of water in a vortex. From the travels of Monconisius we learn that it was already the thinking of Torricelli (and, as I suspect, of Galileo also, who was his pupil) that like chaff or straw floating on water, so the stars, in their own medium, rotate around their own center more or less quickly.
>
> But it is not difficult for such general matters to come

into the mind. It has thus been proposed by us to develop these laws of motion more clearly. This will teach that the subject of the investigation is much more profound. And since a certain light of this sort struck us, and the investigations seemed to have been completed quite neatly and naturally, I have been uplifted in the hope that the true causes of the motions of the heavens had been approximated by us.

From the extraordinary thinking of Gilbert it is also established that every large body of the universe, to the extent known by us, reproduces the nature of a magnet, and in addition, that the aligning force, with respect to certain poles, has the power to attract related (very small) bodies into its sphere. We call this *gravity* in things which pertain to the earth, and transfer it, by a certain analogy, to the stars. But, what the true cause of a phenomenon manifest so widely might be, and whether it is the same as in a magnet, is not established well enough.

While the problem cannot yet be solved with a proof, we do nonetheless have phenomena which agree with each other in a wonderful way, and are recommended by their great likeness. It can, of course, be asserted that the attraction of heavy bodies is brought about by some bodily radiation, for immaterial things ought not to be employed to explain physical phenomena. Then it is consistent that there is, in the body of the globe, an explosive impulse of matter away from matter which is unlike it or disordered [in contrast to] matter which is in agreement with it and has a motion of its own type, so that it is attracted by the rotating impulse. . . .

In this way different causes which have been assigned to explain the fluid motion, come together so that we simultaneously have the centrifugal force, spherical radiation, the magnetic attraction, the blowing apart of what is disorderd, the internal motion of the fluid, and the rotation of the field.

But, whatever the cause of gravity, it is sufficient for us that a globe which attracts, thrusts out material rays analogous to rays of light, or that in every direction, it emits impulses along lines which move away from the center. This does not occur in the same way as would be necessary for parts to fall from the earth to the depths, but as an impetus is propagated by matter impelling continuous matter, as in light and sound, and in the motion of a fluid. Therefore, those for whom it be a settled matter that the propagation of a perceptible effect can be accomplished instantaneously, are in error. . . .

A short time ago it was proven by learned men [by Kepler, in fact] how bodies are illuminated by light in an inverse ratio to the square of the distances. It should be said that bodies are also attracted by gravity in the same way, by so much less the greater the square of the distance is from what is attracting. [That is, the attraction varies inversely with the distance] The ratio of both is calculated in the same way.

Thus, let concentric spherical surfaces be described around a lighted or radiant center *R* [Figure 4]. Parts of these surfaces, made from the similar arcs and similarly located points *ABC*, *LMN*, are cut through at points *A* and *L*, or by the straight lines *RAL*, *RCN*, and rotated around the radius or axis bisecting the arc *RBM*. Next, the light, or attractive force, is uniformly diffused over each surface, or equal parts of the same surface are equally illuminated or stimulated. In this way, the whole light or force on the surface *ABC* is in a ratio to the light or force on the surface *LMN*, which is composed out of the intensity or the illumination and the extent of the surface. But the light, or attractive force, on the surface *ABC* is only as much as is on the surface *LMN*, therefore the intensities are inversely as the extent. That is, the illumination, or pull of gravity, is inversely as the surface. But the surfaces *ABC* and *LMN* are as the squares of the diameters *RA* and *RL*. So the illumination, or the pull of gravity, is inversely as the squares of the distances from the center of radiation or attraction.

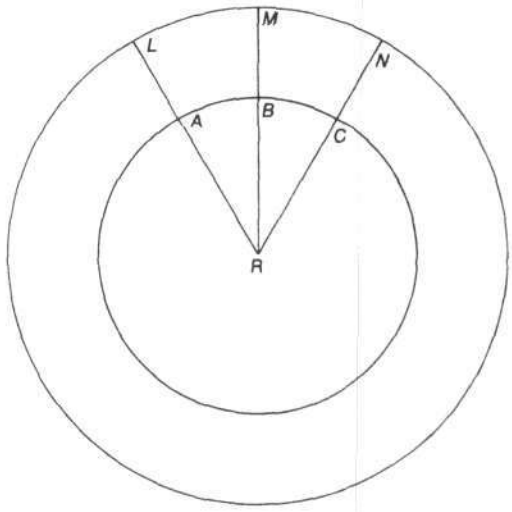


Figure 4
DERIVING GRAVITATIONAL ACTION
The gravitational action is the square root of the distance from the center to the perimeter of the circle. Leibniz's diagram demonstrates that the gravitational field diminishes and can be considered to be spread out over the area of concentric circles so that the field intensity will be the inverse of the area at any given position, such as A or L.

The Universe Is Harmonic

Leibniz then proceeds to deduce the same law, as he says, *a posteriori*, using his method of the analytic calculus. Although he indeed describes the gravitational impulsion according to the inverse square law, Leibniz adapts his mathematics to his vortical hypothesis and adopts a rotating frame of reference, rather than treating space as an absolute Cartesian grid in the manner of Newton. He therefore

decomposes the elliptical planetary orbits into three separate motions.

First, there is circular motion that imposes a circular orbital velocity to the planet. This varies reciprocally with the distance of the planet from the Sun. Leibniz names this a harmonic function. It is this harmonic rotation that produces the conservation of angular momentum, otherwise expressed as Kepler's second law.

Next, there is the interplay between the centrifugal motion arising out of the rotation and an additional gravitational attraction. These, of course, are radially vectored. Once Leibniz has derived the gravitational force, he has then established that his harmonic circulation function is in fact the potential function. Thus the rotation of the vortex creates the potential function from which gravitational action may be derived mathematically, as a first difference between neighboring circles.

Leibniz derives Kepler's law in a simple geometric manner and then writes:

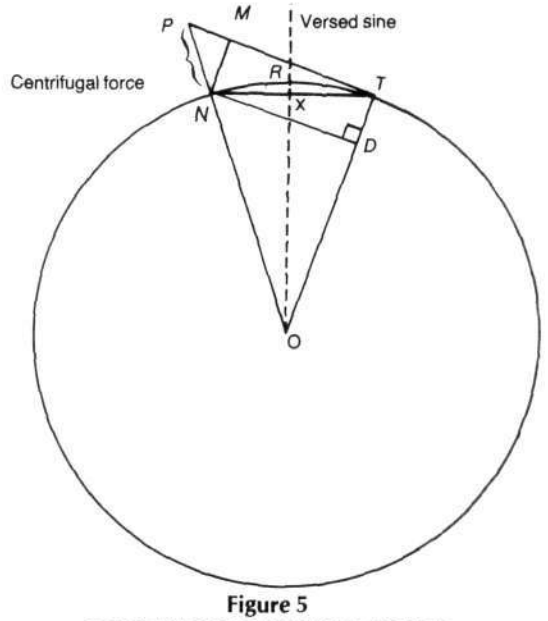


Figure 5
DERIVING CENTRIFUGAL FORCE

The differential triangle was a device used in the days before Leibniz developed the calculus. In this proof, the idea is to take a finite triangle and decrease it until it becomes "infinitesimally" small. In this triangle, NT *represents the velocity, the radius of the circle is* RO, *and* RX *is called the versed sine.*

The formula is derived by taking the simple Euclidian equation that states that $RX \times XD = NX^2$. *The trick is that as* N *approaches* T, RX^2 *is considered to be "ignorably" small and therefore can be discounted, to give an approximate value* $RX \times RD = NX^2$. *The formula for the centrifugal force follows from this:* $PN^2 = NX^2$ *divided by* R. *Note that as* N *approaches* T, NM *is considered to be equal to* PN *and parallel to* RX *and* TD.

It now follows from the above that *the planets are moved by harmonic rotation* (not only the primary planets which rotate around the Sun, but the satellites around their primary planets), as if around a center. For observation shows that when radii are drawn from the center of rotation, they describe areas proportional to the duration of the rotation. . . . It is also consistent that *the aether or fluid orbit and its planet are moved by harmonic rotation*; for it was shown above that no body moves in a fluid along a curved line on its own. Therefore there the aether must also rotate, and it is consistent with the rotation of the planet to believe this to be the cause of its motion, so that the rotation of the aether and its planet would also be harmonic.

In some way the aether and planet must disturb each other. For it is credible that when the planets are carried around in some matter, their interaction should be perceptible with respect to their density, which would produce a contrary tendency or resistance to the movement. Nevertheless the common path of the planets is convincing evidence that this is given as a common fluid orbit which carries all the planets. . . .

We would establish in this way that *a planet is moved by a twofold motion composed from the harmonic rotation of the orbit of the fluid which carries it and from radial motion*, as if from its gravity or attraction, that is *its impulse toward the Sun or primary planet. . . . Now that harmonic rotation has been explained we must come to the radial motion of the planetary system, which arises from the combination of the outward pushes which result from the rotation and the solar attraction.* Although it is permissible to call this latter attraction, it should really be described as an impulse; for the same reason that we can conceive of the Sun as like a magnet, since magnetic actions are derived without any doubt from the impulses of fluids. We will name the *disturbance of gravity* from this, conceiving of a planet like a heavy body which tends toward the center, that is the Sun; with the proviso that this type of orbit is governed by a special law of attraction. We should therefore see what the law of attraction does to an elliptical line, and it is necessary, as we follow this up to enter the inner sanctuary of Geometry for a short while.

Leibniz then proceeds to show the derivation of centrifugal force. Since centrifugal force varies as the square of the velocity divided by the radius, and in a Keplerian orbit the velocity is inverse to the radius, it will vary as the inverse cube of its radius. He then equates the centrifugal force to the constant area swept out by a radius in a given amount of time, to show that the centrifugal force will be equal to the square of that area (equivalent to the angular momentum) divided by the cube of the radius.

He then establishes a proportionality between the ratio of the orbital to the rotational velocity of a planet and its distance from the major axis of the ellipse that it sweeps out, and also between this first ratio and the mean proportional between the focal distances of the rotating planet. These proportionalities are used in the derivation of the

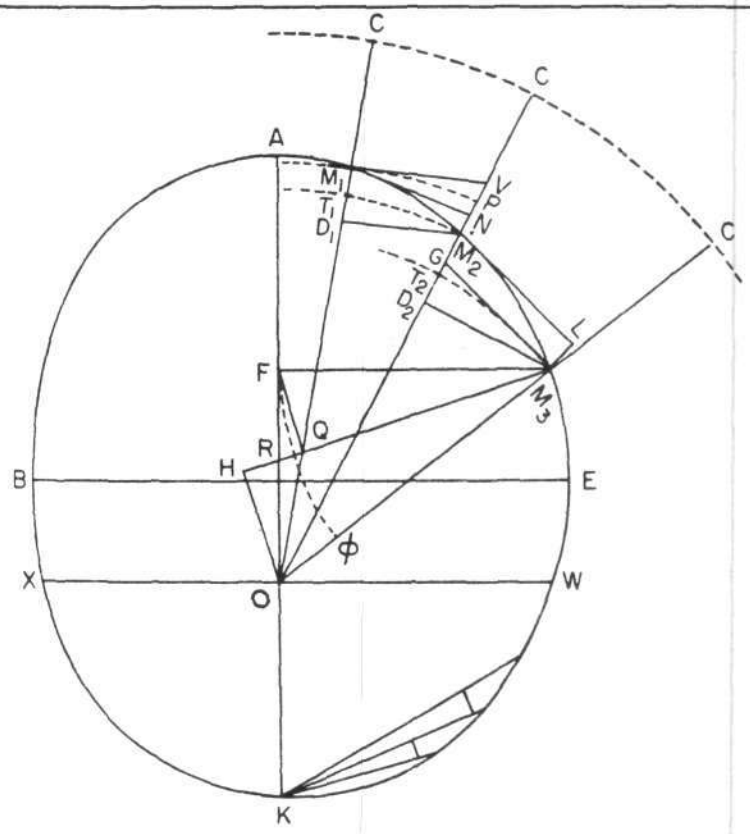


Figure 6
LEIBNIZ'S ILLUSTRATION OF CELESTIAL MOTION

Leibniz used this diagram to illustrate the motion of a planet in orbit. The motion is determined by the interplay of the centrifugal and gravitational force and the harmonic circular rotation of the ether. Centrifugal force would equal T_2G and the gravitational force would equal GM_2. The three dotted lines shown are circles on the ellipse. Arc T_1M_2 and arc T_2M_3 which are on the circumferences respectively of two concentric circles.

Leibniz's development of where e^2, p^2, and so on, are, comprises the rest of the translation excerpted here. Obviously with the excerpt alone, readers cannot confirm the entire derivation. The terms used are derived from geometric methods based on the use of differential triangles and similarity relations among them. The excerpt is presented here to demonstrate how Leibniz utilized his calculus and to emphasize the contrast between his method and Newton's.

common manner of the time, by reducing finite areas to their differential triangles (Figure 5). With this accomplished, Leibniz proceeds to his derivation of the $1/R^2$ law. This section is reproduced here in full for its general interest, because it shows how Leibniz applied his method of the calculus to solve the problem and how his calculus is in sharp contrast to Newton's intuitive methods. More detail can be found in Figure 6. Leibniz writes:

> *If what is moving has gravity, or is attracted to some* center, as we assume a planet to be with respect to the Sun, it will be carried in an ellipse (or another conic section) by harmonic rotation, and the center, whether of attraction of of rotation, would be in a focus of the ellipse. The attraction, or gravitational disturbance, will be as the squares of the rotations directly, or as the inverse squares of the radii, or the distances from the focus.
>
> We discover this in the following way using a not inelegant example of our Calculus of Differences or Analysis of Infinites. Let $A\omega$ be q; OF, e; BE, b (that is the $\sqrt{[q^2 - e^2]}$); the radius OM_2, r; $O\phi$ (or $OM_2 - FM_3$) $2r - q$, or by the shorthand p; and let WX, the latus rectum, be a equal to $B^2:q$.[4]
>
> Let twice the part of the area, or twice the triangle $M_1 M_2 O$, which is always equal, be τa, with a assumed from the latus rectum, τ will represent a period of time which is always equal, and D_2M_3, the rotation, will be $\tau a:r$. Next let the difference between the radii D_2M_2 be called dr, and the difference between the differences, d^2r. But by the preceding, dr (or D_2M_2) is to $\tau a:r$ (or to D_2M_3) as the $\sqrt{(e^2 - p^2)}$ is to b. Therefore, $brdr = \tau a\sqrt{(e^2 - p^2)}$ is the difference equation. The differentio-differential equation (difference-of-the-difference, or second difference) equation for this, according to the laws of the calculus which I have introduced, will be dealt by us in this special section.
>
> As developed above, the equation is $bdr\,dr + br\,d^2r = -2\,pa\tau\,dr:\sqrt{(e^2 - p^2)}$. The dr should be canceled out of both sides of the equation, so that only d^2r remains. This would give $d^2r = (b^2a^2\tau^2 - 2a^2qr\tau^2):b^2r^3$, which was asserted. For d^2r, an element of the radial velocity is the difference between $b^2a^2\tau^2:b^2r^3$, that is $a^2\tau^2:r^3$, which is twice the centrifugal force,[5] and $2a^2qr\tau^2:b^2r^3$, that is (since $b^2:q = a$) $2a\tau^2:r^2$.
>
> Therefore the gravitational disturbance must be $2a\tau^2:r^2$ [actually the factor of 2 is in error] which when multiplied by the constant $a:2$ gives $a^2\tau^2:r^2$, the square of the rotation. Therefore, the gravitational disturbance is as the square of the rotation directly, and therefore as the inverse square of the radii. The same conclusion follows in the case of the hyperbola and parabola, but most of all in the case of a circle, which is the simplest ellipse. However, the cause of the difference between these conic sections, and when circles and ellipses are generated before the others, will appear below.
>
> If someone wanted the example of the calculus we

show here to be explained to themselves more clearly, especially because we developed the differential above but made no mention of the second differential, as if it flowed from the former, they shall have the following. In the differential equation $brdr = \tau a\sqrt{(e^2 - p^2)}$ (1), m is written instead of dr for reasons of conciseness, and n is written for $(e^2 - p^2)$, which will give $brm = \tau a \sqrt{n}$. The differential equation of this equation (that is the absolute second differential) from the new general algorithm handed down by us, is $brdm + bmdr = \tau a\, dn : 2\sqrt{n}$ (2). But m is equal to dr, and then $dm = d^2r$, and since $n = (e^2 - p^2)$, thus $dn = 2pdp$, but $dp = 2\,dr$, since $p = 2r - q$ (for $M_3O - M_3F$ = twice $M_3O - A\omega$). Thus by substituting the values discovered for m, dm, n, dn in the second differential equation (2), we will have $brd^2r + bdrdr = -2a\tau pdr : \sqrt{(e^2 - p^2)}$ (3).

In this case, by substituting τa: br for $dr\sqrt{(e^2 - p^2)}$ from equation (1), and by substituting $\tau^2 a^2(e^2 - p^2) : br^2$ for $bdrdr$, and by canceling out the fractions from equation (3), d^2r is made equal to $(-e^2 + p^2 - 2pr)\ \tau^2 a^2 : b^2r^3$ (4). Now $e^2 = q^2 - b^2$ and $p = 2r - q$, and thus $-e^2 + p^2 - 2pr = -2rq + b^2$ (5). Therefore lastly, from equation (4) d^2r is made to equal $(-2rq\,\tau^2 a^2 + b^2\tau^2 a^2) : b^2r^3$ (6), or since $qa = b^2$, d^2r is made to equal $\tau^2 a^2 : r^3$, $-2\tau^2 a : r^2$ [sic], or d^2r is the difference between the quantities identified above as $\tau^2 a^2 : r^3$, the square of the centrifugal effort, and $2a\tau^2 : r^2$ the gravitational disturbance by which something moving is kept in orbit.

Leibniz ends his paper by summarizing how the interplay occurs to keep the planets on their elliptical orbits. He ends with the statement:

> If the simple centrifugal force were equal to the attraction, a *parabola* would be produced, if it were larger, a *hyperbola* would be created, the focus of which would be between it and the Sun. If a planet were not endowed with gravity, but with levity, and were not attracted by the Sun, but repelled from it, the opposite hyperbola would be created, and the Sun would be outside its focus. But it has been proven that our planets are not borne in parabolas or hyperbolae, because if they ever were moved in such a way, they would have disappeared into universal space some time ago, since such curves do not turn back on themselves. It should be left to observation to determine whether comets are carried in parabolas, or hyperbolas, or similar curves, or whether their motions are turned back after a long timee toward their previous tracks.
>
> Furthermore the planetary ellipses do not depart to any great extent from perfect circles, and so they fight with each other less; however neither do perfect circles result. Certain planets have greater solidity and power than others, and this effects their composition and distance apart. For the rest, what remains is for us to explain the motion of the solar vortex more clearly, so that the causes and laws of gravity and magnetism could be better understood in that, and radiation might be explained in a more perfect manner a priori.

Viewed as a system, in first approximation, the solar system is a force free system. Yet, as Leibniz showed, although no net work is accomplished, there is a constant interplay between the centrifugal and gravitational force that may be understood as the work done by the planet and the work done upon it. While the circular harmonic orbits represent the simplest least-action function, the elliptic orbits into which they have been transformed also represent a least-action function that allows for the oscillating interplay of work between the orbiting planet and the rest of the universe.

At the end of a completed orbit no net work will have been done, yet the fact that the elliptical oscillation takes place between circular orbits indicates the actual work involved in the creation of the solar system.

Perhaps it seems a moot point now to resurrect Leibniz's treatment of the theory of gravitation. Yet the point is not merely to set the record straight—notwithstanding the fact that without Leibniz there would have been no analytic mechanics. The point is, that without using Leibniz's method, without the using the Platonic method, no fundamental scientific breakthrough has ever been made—nor will one be made in the future. Just as the notion of validity of pure mathematics detached from mathematical physics is a psychotic delusion, so the idea of a physics that merely describes a chain of events is impotent. Mathematical physics must be based precisely on that formulation of Leibniz that was ridiculed by Voltaire: *that this is the best of all possible worlds*. Physics must accord with natural law by searching for those least-action functions by which the universe, and we as its caretakers, may further its perfectibility.

Today, we are still living off the scientific capital of the last great scientist, Bernhard Riemann. If we are to progress, as we must, we must, like Leibniz, ruthlessly attack the enemies of science, the heirs of Descartes and Newton, and we must reestablish the fundamentals of the Platonic method. It is with that task in view that Leibniz's work is significant today.

Carol White is editor-in-chief of Fusion.

Notes

1. This first English translation of Leibniz's 1688 essay in Latin "Essay on the Causes of Celestial Motion" (Tentamen De Motuum Coelestium Causis) is by Christopher White. Copies of the translation in draft form are available from the FEF at $10 each, postpaid. The original essay was published in Vol. 6 of C.P.I. Gerhardt's *Leibnizens Mathematische Schriften* in 1860.
2. Frank E. Manuel, *Portrait of Isaac Newton* (Cambridge, Mass.: Harvard University Press, 1968); Richard S. Westfall, *Never at Rest* (Cambridge: Cambridge University Press, 1980); Gale E. Christianson, *In the Presence of the Creator* (New York: Macmillan, 1984).
3. The earlier editions of Newton's *Principia* were called *The Mathematical Principles of Natural Philosophy*. The Dover edition, called simply *Principia*, was first published in 1934 and reprinted in 1962; see especially, pp. 6-12 of Volume 1 and pp. 543-547 or Volume 7. Newton's *Opticks*, first published in 1704, is available from Dover (1952) based on the fourth edition of Newton's work, published in 1730; see pp. 339-405.
   Keynes's comments can be found in "Newton the Man" in the Newton Tercentenary Collection (Cambridge: Cambridge University Press, 1947).
4. Leibniz here makes a trivial error, writing a rather than $2\,a^2$. This does not affect his further derivation in any significant way, since a is the angular momentum per unit of time, which is constant for a given orbit.
5. This is another trivial error. It is the centrifugal force, not twice the amount.

Bangladesh loses between 30 to 50 percent of its onion crop each year to spoilage and insects—a loss that would be eliminated if the crop were irradiated after harvest. Here Uwe Parpart-Henke examines irradiated shallots (without any sprouts) at the Institute of Food and Radiation Biology at Savar, where the Bangladeshis are beginning to commercialize food irradiation

The Fight for Nuclear Development In Bangladesh

by Marjorie Mazel Hecht

Do developing nations choose low technology instead of advanced technology? The answer is that they are not given a choice. Malthusian institutions like the International Monetary Fund mandate that "appropriate technology" is all that poor countries will get.

How the no-growth lobby blocks industrialization was shown at an International Conference on Physics and Energy for Development held at Dhaka University in Bangladesh Jan. 26-29. At most international conferences like this in developing nations, the academic Malthusians predominate, spreading the lies that "small is beautiful" and that solar energy is most appropriate. Usually, they have a captive audience. But this time, the Malthusians met up with significant scientific opposition—a delegation from the Fusion Energy Foundation (FEF) and *Fusion Asia* magazine—and their game was spoiled.

The FEF group, including research director Uwe Parpart-Henke, FEF European coordinator Jonathan Tennenbaum, *Fusion Asia* editor Ramtanu Maitra, and fusion scientist Winston Bostick, was invited to participate in the conference by the Bangladesh Atomic Energy Commission, whose chairman, Dr. Anwar Hossain, is on the editorial board of *Fusion Asia* magazine.

From the very first session, the battle was on—nuclear versus solar power. The audience was most Bangladeshi, about 150 scientists and government officials, with three dozen or so foreigners, for the most part solar experts from Sweden, India, and the Trieste Center in Italy.

Uwe Parpart-Henke led the attack with a hard-hitting presentation on the economics of energy, discussing the question from the standpoint of comparative energy flux density. By the time he finished showing how outlandishly expensive solar and biomass energy are compared to the more-energy-dense nuclear power, smoke was rising from the back of the room.

"It's not true, what you said about solar," shrieked the American solar expert Bernhard O. Seraphin, from the University of Arizona, now on sabbatical at the Trieste Center. But Seraphin could offer no facts to back up his shrieks.

Other solar advocates then argued that energy policies had to be adapted to the social and economic structure. "That's precisely the question," Parpart-Henke retorted. "Are you going to formulate your energy and science policy from the standpoint of adapting to and remaining in the existing social and economic structure or from the standpoint of your future goals, your desired future economic structure?"

As the *Bangladesh Daily News* wrote in covering the conference, "Nuclear energy is the most efficient in terms of energy payback under the present technological development." Of the presentation by Parpart-Henke, the *News* noted that the FEF scientific evaluation shows nuclear has a payback time of 1 year compared to 20.3 years for solar panels or 8.5 years for solar reflectors.

The Key to Development

Here are excerpts from the inaugural speech at the International Conference on Physics and Energy for Development by Lieutenant General Hossain Muhammad Ershad, President and Chief Martial Law Administrator of the People's Republic of Bangladesh.

. . .The appropriate use of energy and power is not only the yardstick of the progress of a country, it is also the key to development. I hope this seminar will succeed in generating fresh enthusiasm and initiatives among the scientists and technologists toward making greater contributions to national advancement.

Today's civilization bears testimony to the talents and sacrifices of the scientists and technologies. Only those nations which have been able to make proper application of the knowledge of science and technology have been able to accelerate their pace of development. An urge and determination to improve the quality of life are the main inspiration behind the work of scientists and technologists. The time-honored contributions and potentialities of science and technology cannot remain limited to a particular class, geographical boundary, or time frame. They are the means to achieve welfare for the entirety of mankind for all times to come. For this reason, I would make an appeal to the scientists and technologists to rededicate themselves to the welfare of the humanity from a universal point of view. I would particularly appeal to them to come forward to the well-being of the teeming millions in the developing countries.

We are engaged in building a happy and prosperous new Bangladesh. This calls for achieving self-sufficiency in all spheres of our national life. We are determined to utilize the fruit of advanced knowledge of science and technology of the world for improving the living condition of our people. We need skilled manpower and a suitable infrastructure for higher science and technology to ensure proper use of the latest developments in this field. . . . We cannot perpetually depend on financial and technological assistance from abroad. . . .

You are aware that the paucity of the source of energy stands in the way of our overall development. At present natural gas is our main commercial fuel. The country's natural gas wealth has to be used in such a way as to derive maximum benefit out of it. . . . In view of the high oil prices, we have to think of the alternative source of nuclear power production at low cost. We believe that there is a necessity for installation of an atomic reactor in the western region of our country. Of course, it is a problem to arrange initial funds for the installation of such a project. The government, however, has been continuing its efforts to procure funds for the project. I am happy to know that this conference will discuss various aspects of the use of this technology. I believe the deliberations of this conference will go a long way in helping the developing countries in the peaceful use of atomic energy.

The country's first experimental atomic research center is being installed at Savar shortly. A substantial part of the implementation work of this project has been done by our own scientists and technologists. This is undoubtedly a laudable effort. I believe this reactor will provide training facilities and help build infrastructure for our programme in this regard. . . .

The extent to which the Malthusian solar advocates from the West have brainwashed their captive audiences in developing nations—using, among other things, "conditionalities" attached to grants from agencies like the U.S. Agency for International Development—could be seen in the next session: a fierce academic debate over how to measure the amount of solar energy falling on any given spot of land at any time! Not surprisingly, each of the developing sector participants on the panel had studied with one or another Western solar professor.

Solar Fakery and the Trieste Mafia

The message from the Malthusian scientists, particularly those connected to the Trieste Center in Italy, was stick to low technology, or else. For example, solar expert Seraphin responded to the Parpart-Henke presentation: "These findings cannot be judged as the end of photovoltaics. A lot of research must be done. Bangladesh *must* join this club of researchers."

This same message was conveyed via telegram to the conference by Abdus Salam, leading Malthusian ideologue at the Trieste Center: "Growing energy demands and the trend of increased fuel prices make it imperative for less developed countries to expand and control their indigenous resources. This . . . is particularly true of nonconventional energy—solar energy conversion—whose final success will depend on high-level science."

Salam brings many scientists from developing countries on scholarships to the Trieste Center, where a kind of solar club is formed to perpetuate the solar hoax when they return to their countries.

The solar presentations by proponents of this hoax were marred by slipshod research and outright lies. One chap from the University of Kalyani in India, for instance, when his fishy data were questioned, replied that the figures for solar energy batteries as opposed to dry-cell batteries looked so attractive because "I favor solar energy."

Other solar experts made it clear that they were not at all interested in supplying commercial or industrial power, but only agricultural power—and even then only "traditional" agricul-

"The epitome of ridiculousness" is how Fusion Asia *editor Ramtanu Maitra (above) characterized this $16,000 solar-powered pump, that goes limp as soon as a cloud covers the Sun.*

ture, a euphemism for manual labor and rudimentary tools.

Another Indian professor from Kalyani University discussed a solar "power plant" composed of photovoltaic panels spread out over a vast area of land. One Bangladesh scientist politely asked what would happen to the acres of panels during the three months of the year when Bangladesh was subjected to severe hail storms. "Why, the solar panels would have rickshaw wheels, and could just be wheeled into a nearby warehouse," the solar advocate said. Incredulously, the Bangladeshi replied, "You mean, every six hours for three months. . . ."

One of the Indians pompously put forward the thesis that Bangladesh—which uses only one-tenth the energy per capita as other Asian nations and is one of the most densely populated nations—actually uses as much energy as any developed nation, if you count the "hours of clothes drying in the Sun or sailboats sailing in the wind." Another in the Indian delegation declared that India was "going solar" after making the mistake of pursuing high technology solutions—a lie countered by Ramtanu Maitra, editor of *Fusion Asia* magazine in New Delhi.

Maitra also refuted the British study touted by the World Bank that says nuclear power costs $2,930 per kilowatt, which is more than 2½ times what it cost India to build its nuclear plants.

Will Nuclear Power Prevail?

Despite its group of Trieste-Center-trained advocates of solar power at Dhaka University, Bangladesh also has a faction of scientists and leaders who understand that nuclear energy is the only way to industrialize and bring Bangladesh out of the Dark Ages. As these pronuclear spokesmen noted, for Bangladesh the question of going nuclear is far from academic; it is one of life or death. Bangladesh is the most densely populated nation in Asia, and yet consumes a miniscule amount of energy, about one-tenth of the average for Asia, according to Atomic Energy Commission head Dr. Hossain.

There are indications that the nuclear faction will win the battle. The conference was opened by Bangladesh President Lt. General Ershad, who made a strong argument for advanced technology. "In view of the high oil prices we have to think of the alternative of producing nuclear power at a low cost," Ershad said.

"We believe it is a necessity to install an atomic reactor in the Western region of our country. Of course the problem is to arrange the initial funding for the installation. The government has been continuing efforts to procure funds. . . . The country's first experimental atomic research reactor is being installed at Savar. Undoubtedly it is a laudable effort. I believe that this reactor will provide the training and infrastructure for our nuclear power program."

The vice chancellor of the University of Dhaka, Professor Shamsul Huq, also argued for advanced technology in his opening remarks to the conference. "The slogan of appropriate technology was created a few years ago as a euphemism for updated traditional technology. The concept was probably well

intentioned, but it was based on the unacceptable premise that the technology gap cannot be bridged."

Without a doubt, the FEF intervention at the conference polarized the situation, and will continue to have an effect. After the first panel, for example, the panel chairman, Dr. Nazrul Islam, invited Parpart-Henke to speak further with the Bangladesh Planning Commission on the question of energy flux density. The commission is drafting its Third Plan including a major new policy on science and technology.

At the plenary session of the conference, Anwar Hossain spoke for an hour summarizing all the energy options and then endorsing nuclear as the most advantageous for Bangladesh. Hossain, who has been fighting to develop a nuclear plant in Bangladesh for more than a decade, described the specifics of nuclear economics. "Admittedly nuclear plants are capital intensive, but the fuel cost is so low that the extra investment can be recovered in a matter of a few years. . . . The further development of atomic power, especially the fast reactor and fusion, will lead to inexhaustible sources of energy."

The Nuclear Option

Already the advantages of nuclear power are being explored and practiced at the Institute of Food and Radiation Biology at Savar, where the Bangladeshis are beginning to commercialize food irradiation for preserving crops and fish and to develop other advanced nuclear technologies. Fresh fish, potentially a major source of protein in the area, for example, will keep refrigerated for 21 days once irradiated. At present the Bangladeshis are exploring packaging materials to prevent the reinfestation of irradiated dried fish, and are studying large-scale storage and transportation.

The economics of such research are obvious in a tropical country, where a large percentage of basic crops and foodstuffs is lost to insects and rot. To take one example, at an international conference on food irradiation in Washington, D.C. March 4, the Bangladesh Atomic Energy Commission presented a paper summarizing the results of its studies of low-level irradiation of onions. Onions are a seasonal crop, with the peak harvest in late March, and during the next several months in storage, between 30 and 50 percent of the crop is lost. There is then a shortage of supplies and a price hike for this basic commodity, and the government has to import onions. Low-level irradiation inhibits the sprouting of the onions, thus eliminating the high loss of the crop.

In contrast to the advanced nuclear research, there is also a solar-powered pump project at Savar, which costs $16,000 to build and puts out a peak 1.5 kilowatts—about $10,500 per kilowatt installation cost. As Ramtanu Maitra noted when the FEF delegation visited Savar, the solar panels were coated with dust and had to be cleaned constantly. Furthermore, as soon as a thin cloud covered the Sun, the pump went limp. "A solar power plant would have to be 500 times this size," Maitra said. "That's the epitome of ridiculousness."

We Have to Make A Nuclear Beginning

Excerpted here is the address of welcome to the conference by Dr. Anwar Hossain, chairman of the Bangladesh Atomic Energy Commission and president of the Bangladesh Physical Society.

. . . The per capita commercial energy use of Bangladesh is about 50 kg of coal equivalent and per capita electricity consumption is about 30 Kwh. In comparison, the Asian average per capita consumption in 1981 was 597 kg and 519 Kwh, while the world average was 1,893 kg and 1862 Kwh, respectively. Our energy consumption is roughly 0.5 percent of that of developed countries and only one fourth of the consumption in the neighboring countries like India and Pakistan. On top of this, most of the energy used is noncommercial. Since agricultural and forest resources account for a substantial part of traditional sources, our ecology and environment is being adversely affected with the increasing use of noncommercial energy. We cannot afford to lose our agricultural and forest wealth any further. For faster growth of energy consumption, we have, therefore, to develop commercial energy sources. This calls for intensifying efforts to explore and exploit conventional energy sources and then look for new and renewable resources. . . .

While we keep on exploring our land for new conventional sources, we should realize that the presently known reserve of exploitable resources is much less than our needs for energy that can ensure even a modest growth of our economy. With imported oil prices beyond the reach of our economy, we have to look for alternate fuel. Nuclear energy is now considered to be proven technology for production of electricity. Nuclear power plants are highly capital intensive, no doubt, but the fuel cost is so low that the generation cost is comparable if not cheaper than other alternatives. The extra investment for a nuclear plant could be recovered in a matter of few years' savings on fuel cost. It is true that a number of technical and other issues have constantly to be attended to, but we have to make a beginning with this source of energy, which has a big potential and is expected to last a long time globally. The conference has devoted a full session to discuss all aspects of nuclear power, including the spin-off benefits. Further development of the power of the atom, especially in the fields of fast reactor technology and fusion energy, will lead to an almost inexhaustible source of energy. . . .

SP 100—Space Challenge

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systems for load peaking and emergency power. The new materials alone create the conditions for developing the second-generation nuclear reactors that should have been operating today—breeder reactors and high-temperature reactors—but have been politically sabotaged.

One important example of technology transfer from the stringent space requirements to an improved ground-based system, was in the field of nuclear fuel. The need to achieve very high temperatures in the space nuclear reactor led to the development of beaded fuel particles—highly enriched uranium cores coated with graphite, embedded in a graphite structure. The coated fuel particles became the basis of the high-temperature gas-cooled reactor effort, HTGR. Later in the NERVA program, a composite of uranium-zirconium carbide combined with graphite was used as the fuel matrix, which found application in the Liquid Metal Fast Breeder Reactor or LMFBR research program.

Had these two nuclear technologies been commercially developed, we would now have breeder fuel factories supplying reactors with a cheaper, reliable source of fuel, and HTGRs providing high-temperature process heat for new industries.

For example, electrolytic production of hydrogen and many other chemical processes become economically feasible using higher reactor temperatures. The General Atomic Company, which developed the fuel elements for NERVA, has designed HTGRs to supply manufacturing plants directly with high quality process heat, rather than increasingly expensive fossil fuels.

NERVA and related programs created heat pipe and thermionic and thermoelectric conversion technologies that could be used in Earth-based electric generating plants. These direct conversion techniques, along with magnetohydrodynamic (MHD) conversion, should be replacing the 100-year-old rotating turbines and generators still used in power plants today.

The space nuclear programs of the 1960s developed dozens of new materials, including electrode materials for MHD generators, copper pipes coated with layers of superconducting materials for more efficient transmission of electrical energy, and graphite and composite materials with controlled physical properties for military reentry vehicles.

The SP-100 program now promises to advance these technologies even further, taking fission to higher temperatures and new regimes. It gives the United States a second chance to commercialize second-generation fission technologies, as has Japan, Europe, and the Soviet Union. Ironically, at this point, the potential also exists to leapfrog into the fusion era, via the third-generation nuclear technologies of the fission/fusion hybrid.

'Wire in the Sky'

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originator; that is, that both are of the same generation?

Laser beams destroy their targets by either burning or blowing a hole through them. The energy flux density required for this can range from the deposition of thousands of joules of laser energy per square centimeter for thin-skinned missile boosters to hundreds of thousands of joules per square centimeter for hardened reentry vehicles (RV) that carry the missile warhead through space.

Charged particle beams can be far more efficient. High-energy particle beams deposit their energy not on the target surface, but deep within its interior. And this target penetration cannot be shielded against because it is always possible to "tune" the particle beam energy to penetrate any target to the desired depth.

The interior of the reentry vehicle is densely packed with delicate electronics, and even minute amounts of charged particle energy can disrupt or destroy these electronic elements. A recent Los Alamos National Laboratory study on beam weapons demonstrated that the specific range is that a few tenths of a joule of charged-particle energy deposited per gram of mass of the target will disrupt the electronics, while a few joules per gram will destroy them.

The total amount of charged particle energy needed depends on how well-focused the beam is. For example, if the beam is only a centimeter in diameter, just a few hundred joules of the properly "tuned" particle beam can achieve an assured electronic kill.

Such electronic kill advantages are particularly characteristic of high-energy ion beams. For this reason, neutral beam accelerators have always been seriously considered as potential beam weapons. However, both charged and neutral ion beam accelerators generally have large weights, in excess of 50 tons. With the Antigone concept for beam generation, much lower weight electron beam accelerators could be used.

The basic idea is that the laser beam produces both a path for the propagation of the electron beam and the means to generate a well-focused ion beam within the channel. Because the ion beam is being continuously generated within the channel along which it propagates to the target, it could be continuously refocused at the same time.

—Charles B. Stevens

The Young Scientist

Pascal and the Discovery That Air Has Weight

by Paul Gallagher

The history of science is a battle over methods of scientific thought. When the technologies or insights developed by great scientists are handed down to future generations, the continuing battle over method often hides, or even falsifies in the history and science books, the method of thinking that was responsible for those discoveries.

For this reason, it is important to read what the scientists themselves wrote about their work and to beware of the silly stories of how scientists "accidentally" have made great discoveries. This tale of science gives just one example of how such discoveries occur mainly as part of the scientists' effort to prove their hypotheses and increase man's mastery of the laws of the universe.

The fact that air has weight is one of those scientific discoveries that many history books tell you happened "by accident." The demonstration that air, or the atmosphere, is an invisible gas that exerts pressure against heavy fluids, was first understood by the great French scientist Blaise Pascal (1623-1662).

Pascal's scientific work was done during the dark period of the Thirty Years War. At the time, Pascal battled to bring to light his discoveries about atmospheres and vacuums against an antiscience group of Jesuit fathers who sought to mystify nature and encourage superstition. Like the feudal lords who controlled Europe, the Jesuits thought that it would be easier to control the population if people believed in magic and astrology instead of reason.

Blaise Pascal (1623-1662)

The battle Pascal waged was mostly over questions of theology, such as the extent to which a man must take responsibility for his actions, but questions of pure science were also debated. Pascal, a devout Catholic, was ferociously opposed to what he called the Jesuits' "pagan" way of turning "Nature" into a person and then attributing likes and dislikes to Nature as if "she" were a goddess.

Pascal particularly attacked the false explanation, which was then popular, of why a pump will raise water. "Nature abhors a vacuum," was the ignorant opinion. His rejection of such a silly explanation—which was no explanation at all—led him to the discovery that air has weight. It may be hard to believe now, but in the 17th century people thought that air did not have weight. Instead, the common belief was that air had an innate tendency to seek its special place in the heavens. According to this view, all matter was preassigned a particular place that it then naturally sought out.

The Well-Planned 'Accident'

The pressure of the atmosphere was proved in a famous mountaintop experiment that Pascal designed. The experiment was performed by Pascal's brother-in-law, M. Perier, on the Puy de Dome, one of the highest mountains in Auvergne in France. Even today some still claim that Pascal's discovery was merely a lucky consequence of an accidental mountaintop observation by his brother-in-law, who was a councilman of Auvergne and not a scientist.

In truth, Pascal had devised the ex-

TALES OF SCIENCE

periment in detail and instructed Perier how to do it in a letter that Pascal printed at the time. So well planned was this "accident," that Perier wrote Pascal in his account of the experiment:

"I gave notice of my intention to several persons of condition in the town of Clermont who had asked me to let them know the day when I would go up, of whom some are churchmen and others laymen . . . all very capable men not only their professions but also in all good learning, with whom I was delighted to carry out this fine project."

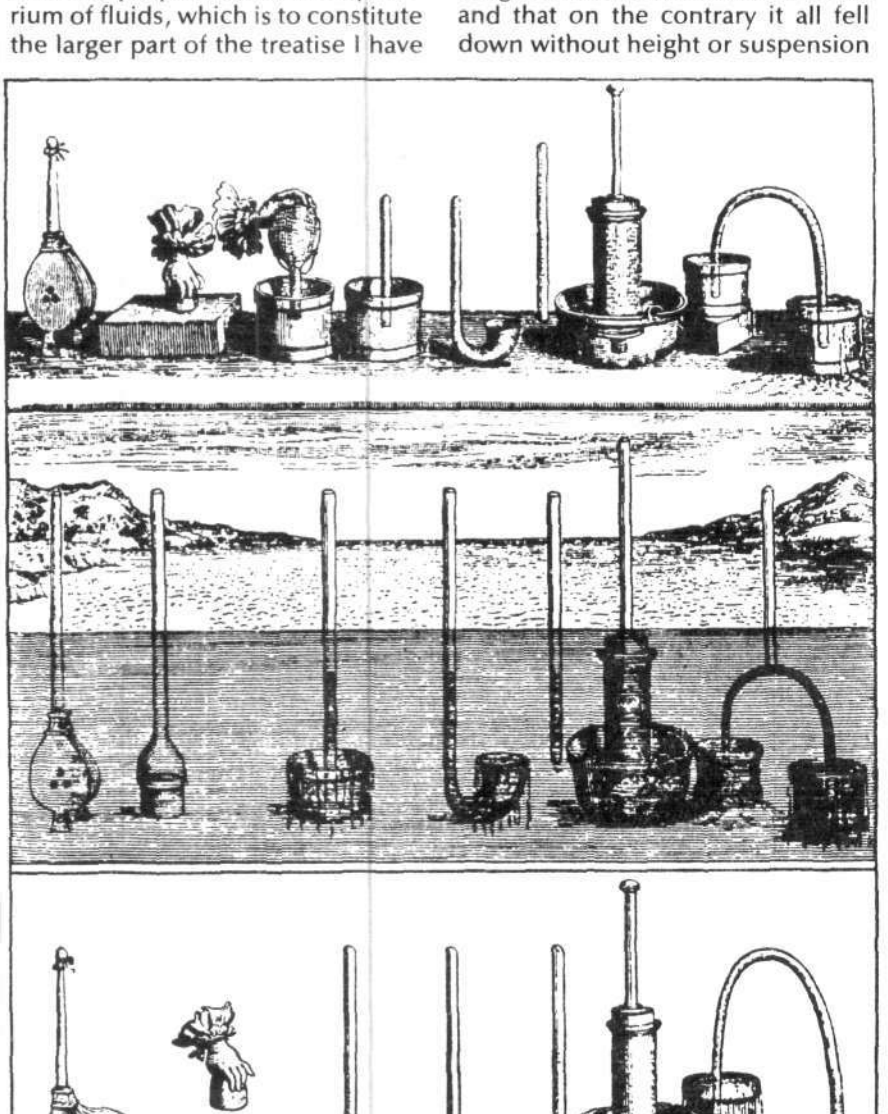
It was not easy to carry out the project, as Pascal wrote to Perier: "But as great things are ordinarily found to be accompanied by difficulty, I anticipate much of it in carrying out of this plan which requires that an unusually high mountain be picked out near a city in which there is a person capable of bringing to this test all the necessary accuracy. For if the mountain were distant, it would be difficult to carry to it the vessels, the quicksilver [mercury], the tubes, and many other necessary things, to undertake troublesome journeys as many times as might be required for finding on the mountaintops clear and suitable weather, which is not often met with there."

'Abhorrence of a Vacuum'

Here is how Pascal described the his hypothesis and the planned experiment in a letter Nov. 15, 1647 to his brother-in-law:

"I am now trying to . . . find experiments which will show whether the effects attributed to the abhorrence of the vacuum should really be attributed to it, or whether they should be attributed to the weight and pressure of the air; for, to tell you frankly what I think, it is hard for me to believe that nature, which is not animate or sensitive, is capable of horror, since the passions presuppose a soul capable of feeling them, and I incline much more to impute all these effects to the weight and pressure of the air, because I consider them only as particular cases of a universal proposition on the equilibrium of fluids, which is to constitute the larger part of the treatise I have promised. . . .

"I could not give you better evidence of how circumspect I am before giving up ancient maxims than to remind you of the experiment I recently made in your presence with two tubes, one inside the other, which demonstrates a vacuum in a vacuum. You saw that the quicksilver in the inner tube remained suspended at the same height as in the ordinary experiment, when it was counterbalanced and pressed by the weight of the whole mass of the air, and that on the contrary it all fell down without height or suspension



A sample of the drawings Pascal used to illustrate his 1647 experiments on the weight of air.

when because of the surrounding vacuum it was no longer at all pressed or counterbalanced by any air, which had been removed on all sides.

"You saw afterwards that this height or suspension of the quicksilver increased or diminished as the pressure of the air increased or diminished, and finally that all the different heights or suspensions of the quicksilver were always proportional to the pressure of the air.

"Certainly after this experiment one might well be persuaded that it is not the abhorrence of a vacuum, as we suppose, which causes the suspension of the quicksilver in the ordinary experiment, but the weight and pressure of the air which counterbalances the weight of the quicksilver. But because all the effects of this last experiment with the two tubes, which are explained so naturally by the pressure and weight of the air alone, can yet be explained with some probability by the abhorrence of a vacuum, I hold to that ancient maxim, resolved however to seek the complete clearing up of this difficulty by a decisive experiment.

"I have thought of one which can of itself suffice to give us the light we seek if it can be carried out accurately. It is to perform the ordinary vacuum experiment several times on the same day, in the same tube, with the same quicksilver, now at the bottom and now at the top of a mountain at least 500 or 600 fathoms high [1 fathom = 6 feet], to find out whether the height of the quicksilver suspended in the tube will be the same or different in the two situations. Doubtless you already see that this experiment will decide the question, and that if it should happen that the height of the quicksilver is less at the top than at the bottom of the mountain (as I have many reasons for believing it will be, although all who have considered this matter are against me), it will follow necessarily that the weight and pressure of the air is the only cause of the quicksilver's suspension and not the abhorrence of the vacuum, since it is perfectly certain that there is much more air pressing down on the foot of the mountain than on its summit; whereas it could hardly be said that nature abhors a vacuum at the foot of the mountain more than at its summit."

The Experiment

The following year, on Sept. 19, M. Perier ascertained that the weather was clear enough to see the top of the mountain and therefore suitable to carry out the experiment. With a group of reputable witnesses, he then performed the experiment at the "lowest place in town," the garden of the Minim Fathers, at 8 a.m. in the morning. First, he poured into a vessel about 16 pounds of quicksilver. Then he placed two 4-foot tubes, sealed at one end and open at the other, into the vessel with the open end under water. He found that the quicksilver left in each of them was at the same level—26 inches.

Then he and his witnesses climbed the mountain, about 500 fathoms, to perform the same experiment, where he found that only 23 inches of quicksilver was left in the tube. By doing the experiment a few times at varying altitudes, Perier was able to tell Pascal exactly how much the quicksilver varied per fathom.

Pascal then duplicated the experiment in the city and achieved the same results. He noted: "This account having cleared up all my difficulties, I do not conceal the extreme satisfaction it gave me. . . . [Now] all students of nature can make the test for themselves at their leisure.

"Many consequences can be drawn from this experiment, such as:

"A way of knowing whether two places are at the same level, that is, equidistant from the center of the Earth, or which of the two has the greater altitude, however far apart they may be, even if they should be each other's antipodes; which would be all but impossible by any other means. . . .

"The unequal pressure of the air, which at the same degree of heat is always much greater in the lowest places."

You can read more about Pascal's experiments with the weight of air in his "Treatise on the Weight of the Mass of the Air," in *The Scientific Treatises* by Blaise Pascal, published in English in 1952 by Encyclopedia Britannica, Inc.

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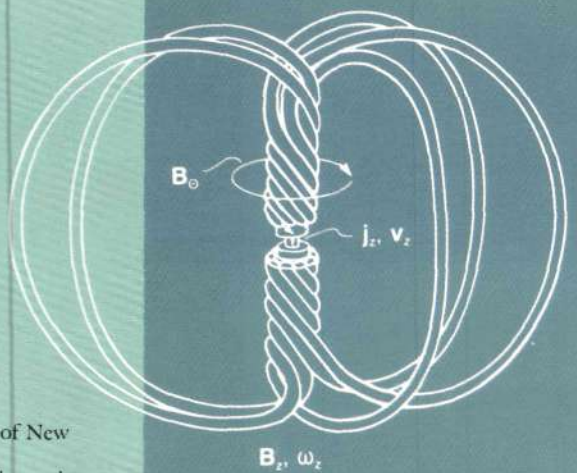

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Courtesy of Dr. Michael Vannier, Mallinckrodt Institute of Radiology, Washington University Medical Center

(a) (b) (c)

Nuclear Magnetic Resonance (NMR), in combination with the computer NASA uses for the Landsat satellite, provides these extraordinary views of a brain tumor. Varying the recording channels of the NMR machine can highlight different kinds of tissues, producing the life-like image in (a) from the images in (b) and (c).

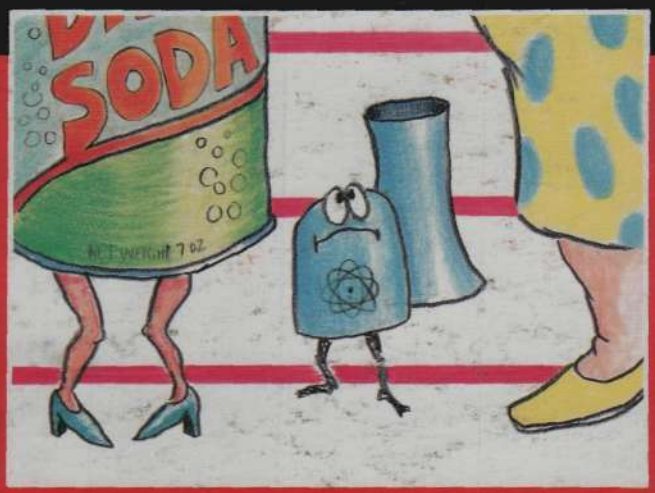

Illustration by Christopher Sloan

In This Issue

Artist's depiction of an SP-100 space nuclear power station attached to a Galileo-type spacecraft launched by the Space Shuttle and destined for Neptune.

Jet Propulsion Laboratory/NASA