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21st CENTURY
SCIENCE & TECHNOLOGY

Vol. 8, No. 3 Fall 1995

Features

Earth First!

What Greenpeace doesn't want you to know: Its ties to Earth First! terrorists were affirmed in a German lawsuit (p. 68).

News

Departments

On the cover: A detail from Raphael's "The School of Athens" depicting Archimedes with a compass; courtesy of the Vatican Museum. Cover design by Rosemary Moak.

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The Hard Truth

In June, 300 anti-environmentalists who came to the Alliance for America meeting to plan strategy to defeat ecoterrorism were treated to a different agenda, including lectures by leaders of Earth First!, the National Audubon Society, and the National Wildlife Fund.

Loggers, ranchers, farmers, miners, and others had come to the Washington, D.C., meeting to fight the Endangered Species Act (ESA), but instead an attempt was made to organize them to support it—with minor reforms. There was nothing wrong with the ESA, they were told, except the failure to properly compensate property owners. Conveniently overlooked was the fact that the ESA is one of a number of environmentalist laws that cumulatively will destroy what is left of our productive economy. Fight big government, not environmentalists, was the message.

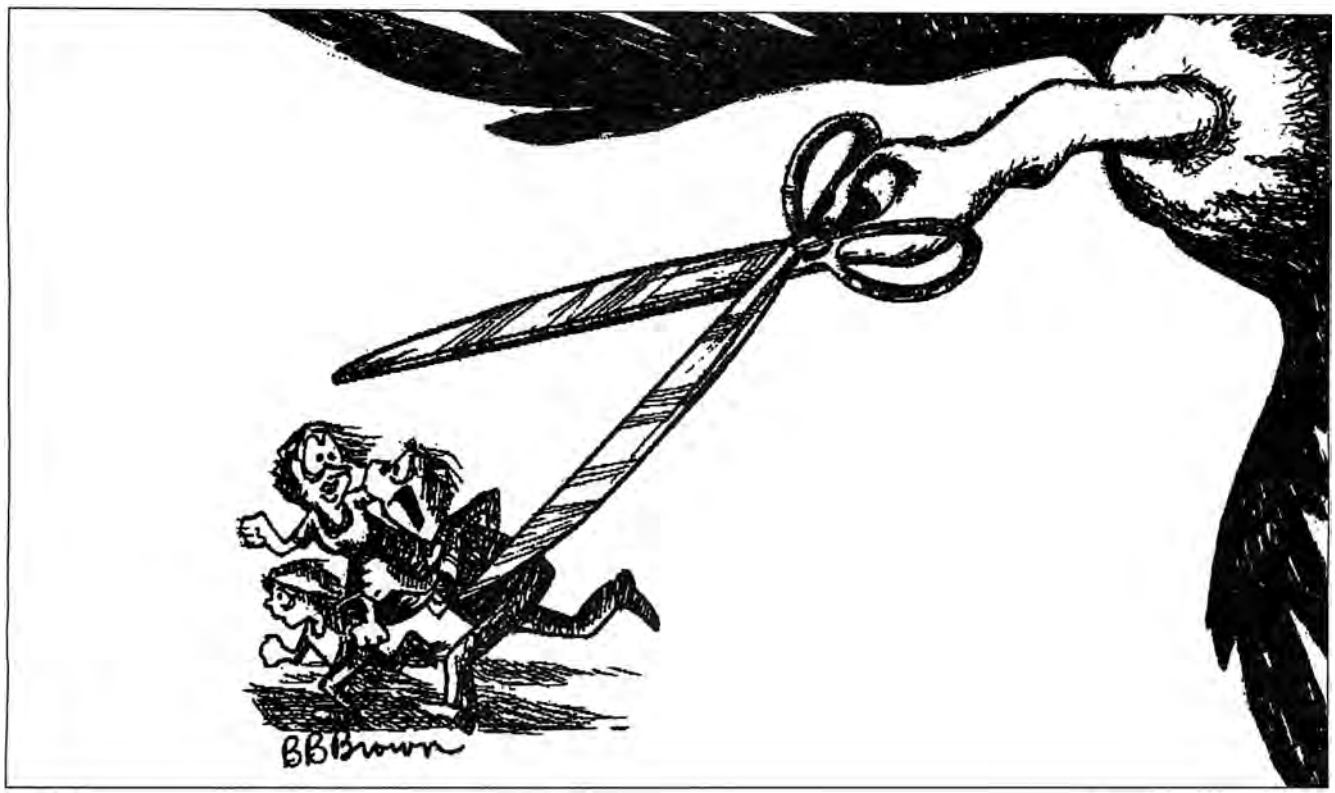
One session on June 11 featured the heads of the Washington state Earth First!, the National Audubon Society, and the National Wildlife Federation. This was an insult to many in the audience who have been the victims of Earth First!'s terrorist activities, while others have been driven out of their homes or businesses by the policies of the Audubon Society or Wildlife Federation. The conference itself was dedicated to the memory of Gil Murray, head of the California Forestry Association, who was murdered in April by an ecoterrorist letter bomber.

It was evident that some conference speakers, in particular those from the Competitive Enterprise Institute (CEI), were actively trying to shift the focus of the anti-environmentalist movement. As CEI spokesman R.J. Smith stated, "conservatives and environmentalists can work together" around their common interests, such as cutting government waste.

'Green Scissors'

The Green Scissors Report, issued in January 1995, exemplifies how conservatives and environmentalists are coming together to shut down America's science and technology capability. Put out by conservative James Dale Davidson's National Taxpayers Union, along with Friends of the Earth, and other green groups, the Green Scissors Report advocates cutting the budget by closing down advanced research in fission and fusion energy and major infrastructure projects. This strange convergence of the environmentalists and conservatives is explicitly based upon a shared opposition to the constitutionally sanctioned powers of the federal government—powers through which this country became the world's foremost industrial nation.

There is a real danger that ideologues pushing the Conservative Revolution can succeed in forging an alliance with environmental radicals on a program of cutting back "big government." But at bottom, radical cuts in the federal budget for social welfare show the same contempt for the sacredness of human life as do the pagan assumptions of the Gaia cult that put mankind on a par with animals.



As can be seen in the Letters column in this issue (p. 4), some readers are disturbed when we tell the truth about the Conservative Revolution. This is because they are unwilling to look at the premises that lie beneath the slogans with which they agree or disagree. For them it is perfectly acceptable to label the greens as fascists—but not Friedrich von Hayek. Yet, von Hayek's philosophy, endorsed by the Conservative Revolution and expressed in the Green Scissors Report, is based on the same fundamental premises endorsed by the greens.

The failure to think through the assumptions that underlie the ideologies with which they may *think* they agree can turn good people into the dupes of individuals who rival Adolf Hitler in brutality. This is why operations such as the Green Scissors Report and the attempted takeover of the Alliance for America June meeting are so dangerous.

Academic Authority vs. Thinking

Another danger is the susceptibility of so many people to be victimized by academic authority. A case in point is economist and Nobel Prize winner Kenneth Arrow, who co-authored a policy paper on world population along with Cornell University professor David Pimentel and others, that appeared in *Science* magazine April 28. (See p. 34.)

Many readers who think that they support family values will be perfectly prepared to accept the argument of Arrow et al. that environmental concerns dictate a maximum sustainable population on Earth, its so-called carrying capacity.

Pimentel, it should be noted, is on record arguing that over the next century, the world's population must be reduced to 2 billion people and the U.S. population reduced to 40 to 100 million. Such "dramatically reduced U.S. population densities would insure individual prosperity and quality environment for future generations," Pimental says in a 1991 paper. Then the United States could become self-sustaining on solar energy.

The article in *Science* is especially pernicious because the average U.S. citizen still tends to accept academic authority. He or she is reduced to a virtual automaton if the self-styled expert puts a mathematical formula on the blackboard.

The vulnerability of the majority of people lies in their failure to examine the basic assumptions behind the ideologies that they take for granted. Unless this situation changes, we will not survive as a nation.

Celebrating Kepler and Riemann

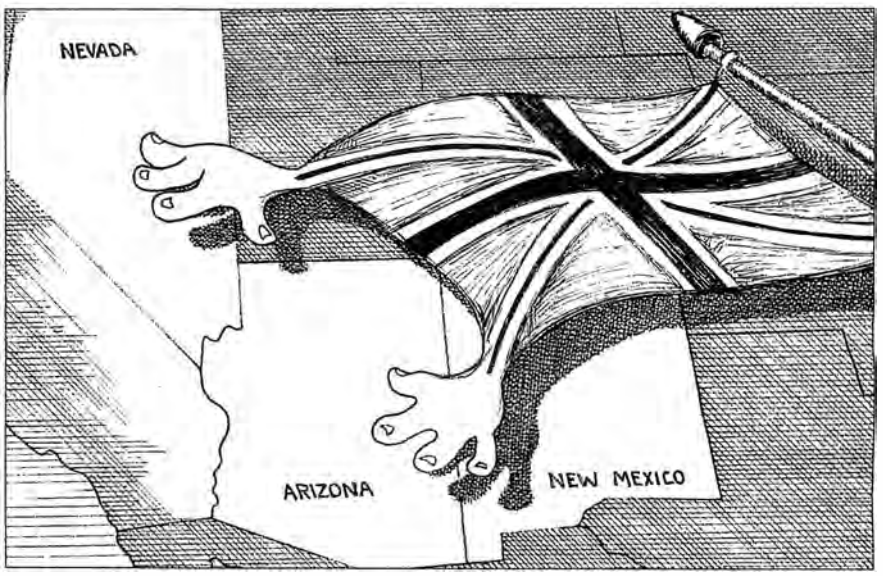
The Winter 1995-1996 issue of *21st Century* will introduce the 400th anniversary of Johannes Kepler's *Mysterium Cosmographicum* with two special articles: a review of Kepler's method by Ralf Schauerhammer, and the first English-language translation of a brief philosophical diary written by the 19th century German mathematician Bernhard Riemann.

The diary is an exceptional statement of the principles that guided the series of Riemann's discoveries in mathematical physics, which, in turn, laid the foundations for the elaboration, at the beginning of this century, of Relativity and Quantum Theory, and at the end of this century, of LaRouche's discoveries concerning physical economy.

Wise Use: A Storm of Comments

EDITOR'S NOTE

We have expanded the letters column to include a selection of comments on the Special Report in the Summer 1995 issue, "A Warning on the 'Wise Use' Movement." Author Anton Chaitkin's reply includes references for further reading.



In Defense of Hayek, Speculators, and the U.K.'s 'Prosperity'

To the Editor:

Concerning Anton Chaitkin's article ["A Warning on the Wise Use Movement," Summer 1995, p. 10]: If Friedrich August Hayek was a fascist, Mussolini was not. Fascism was exemplified by Mussolini's dictum, "Nothing outside the State, nothing against the State." Hayek's position was the polar opposite. One who very nearly singlehandedly fought socialism of both the Bolshevik and fascist varieties for 70 years (and was largely responsible for the renaissance of classical liberalism) should rest in peace free from such calumny. With "friends" like Chaitkin, champions of liberty need no enemies.

For an understanding of methodological conflict between the Austrian school and Historicism (the latter of which was the actual source of both the fascist and National Socialist repudiations of economics *per se,* see von Mises, *Theory and History,* p. 198 et seq.; *Money, Method and the Market Process,* p. 289 et seq.; and especially *The Historical Setting of the Austrian School.*

Socialists started labeling the Austrian school "fascist" soon after von Mises's essay "Economic Calculation in the Socialist Commonwealth" conclusively demonstrated that the implosion of Soviet central planning was inevitable—68 years before the fact. In a futile attempt to evade von Mises's irrefutable proof of the unworkability of central planning, Oskar Lange cobbled together the oxymoron "market socialism," the inspiration for Lenin's NEP, Mussolini's *corporativismo,* and Gunnar Myrdal's "Third Way." Yet von Mises's analysis likewise annihilated the pretensions of all these contraptions, particularly fascism, as Hayek trenchantly observed in *The Road to Serfdom,* et al.

On a related topic, Chaitkin's disparagement of "usury" and "speculators" gives him something in common with the Italian Fascists and German National Socialists. Interest is the opportunity cost of renting money (including inflation, taxes, etc.). "Usury" laws, that is, a ceiling on interest, produce the same effects as any other rent control: a surplus of demand and a shortage of legal supply (for example, the "homeless crisis;" the "credit crunch"), and a lucrative black market to meet the surplus demand (for example, illegal "accessory" apartments, squatters; in the case of loans, "loansharks"). In an attempt to evade these consequences, Nazi and Fascist usury laws required a total system of command economy, including not just rent control but complete wage and price controls.

"Speculators" are, of course, people who transfer risks from producers to themselves, in hopes of realizing a profit. Speculators in cattle futures, for example (those without political clout in Arkansas, anyway), buy in anticipation that the price will rise. If they are wrong, they lose money. By absorbing this risk themselves, they remove this risk from livestock farmers and ranchers, providing them with a relatively stable market from year to year.

The persecution of "speculators" under socialism/fascism—except those in government power or favor, of course (who actually bore no risk at all)—left the risks of market fluctuations directly on the shoulders of primary producers, resulting in a well-documented crisis of risk aversion, which is anathema to entrepreneural innovation. The attempt to stabilize risks without a futures market ("speculators") results again in wage and price controls, which, aside from being oppressive and totalitarian, are useless or downright destructive.

Finally, if privatization is a British plot to destroy any country in which it is implemented, why did Margaret Thatcher implement the world's most aggressive privatization program in the U.K. (reviving the erstwhile moribund British economy in the process)? If privatization is to be repudiated, then whatever is nationalized will stay that way in perpetuity. If

the State can continue to nationalize private property (even through compensated eminent domain) but we cannot privatize State property, sooner or later all property will be in the hands of the State.

The idea behind the Homestead Act, etc. was the opposite—that the federal government has a trust obligation to dispose of public lands. This, by the way, was also the idea behind the Sagebrush Rebellion, of which Nye County was pretty much the heart. Wayne Hage and his Western following have a legitimate grievance: In the states that composed the original 13 colonies, the federal government holds about 3 percent of the land; in Western states like Montana, Nevada, Idaho, Utah, Wyoming, Colorado, and Alaska, the federal government holds some 80 to 90 percent. These Western states are not on an equal footing with their Eastern counterparts vis-a-vis federal power.

Cui bono, indeed? Hage can hardly be blamed for suspecting an Eastern conspiracy to suppress development and competition in the West; after all, Chaitkin posits an analogous conspiracy emanating from the U.K.

Mark La Rochelle
Executive Director
Putting People First
Helena, Mont.

Focus on the Greens At Home

To the Editor:

We don't think Prince Philip and others you mention *can* subvert Wise Users. It's hard to see how agents of British or other foreign interests could possibly channel the thinking of the millions of highly diverse, independently motivated folks or hundreds of loosely-knit groups that make up the Wise Use movement.

But we know for certain that green groups are trying to destroy it. And we know they are heavily funded and highly influenced by America's wealthiest families and corporations.

And we know that local issues—such as outrageous misapplications of the Endangered Species Act, grotesque wetlands dictates, tyrannical regulations which deprive citizens of livelihoods and property, and a host of other governmental abuses—have created massive public resentment which is now focussed mainly on federal authority. We seriously doubt Prince Philip pulled this off.

So why should Wise Users squander their efforts aiming "for the head," as you say, of mostly invisible, possibly nonexistent foes? We have many powerful, giant-sized confirmed enemies right in plain sight.

We admire your tenacity in furthering your message. But we don't agree that the British crown and other foreign-directed enemies are leading us to self-destruction. We're accomplishing that pretty well without them.

Bill Kramer
"The Angry Environmentalist"
Silver Bay, Minn.

Von Hayek and Fascism

To the Editor:

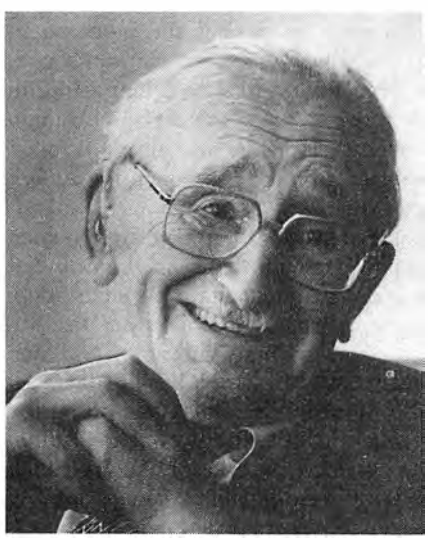
I received my copy of *21st Century* for Summer 1995 the same day I finished reading Friedrich von Hayek's *The Road to Serfdom.*

After reading the excellent piece on Max Planck and a few of the other excellent articles, I read the diatribe by Anton Chaitkin, "A Warning on the 'Wise Use Movement.' "

I have only read two books by Hayek, but *The Road to Serfdom* is about as scathing a denunciation of German socialism under the fascist thugs of Hitler as I have ever read and develops the strong case that fascism or similar totalitarian regimes are an inevitable outgrowth of central planning and control of the economy and of the lives of the citizens. How Chaitkin can dare call Hayek a fascist is beyond my comprehension. I suppose he would characterize Stalin as a "compassionate idealist."

The thesis of Chaitkin proposes is interesting but I can find nothing in his article to provide it with a shred of credibility. To the contrary, his un-cited attacks on the various people only serve to turn my mind to wondering just what axe he is grinding and why.

Harry H. Fries
Vineland, N.J.



◀*"Von Hayek [left] and von Mises were in Britain working for the same British oligarchy (the royal family, Bank of England governor Montagu Norman, and the Cliveden set), which before 1938 had openly promoted Hitler and Mussolini."*

Anton Chaitkin Replies: In Defense of the American Union

Among the responses to my article the interesting objections seem to boil down to these:

• **The postindustrial policy imposed on the United States since the mid-1960s brought about such "local issues" as "misapplications of the Endangered Species Act," and other "regulations which deprive citizens of livelihoods and property." The resulting public resentment "is now focused mainly on federal authority."**

Well, shall we fight to restore the abandoned policy of industrial and scientific progress? Or should we be manipulated, by those who induced the policy change, into fighting against the American Union and our national government?

• **Friedrich von Hayek was "largely responsible for the renaissance of classical liberalism"; he and Ludwig von Mises were "champions of liberty" who argued against totalitarianism.**

Von Hayek and von Mises were in Britain working for the same British oligarchy (the royal family, Bank of England governor Montagu Norman, and the Cliveden set), which before 1938

had openly promoted Hitler and Mussolini. After World War II, the British set up the radical-right Mont Pelerin Society around von Hayek and others to do dirty international operations. The same social and political idea—to roll back civilization to feudalism or worse—was to be expressed by the royal family's radical-left World Wildlife Fund and its subordinate environmentalist movement.

Von Hayek is associated with the doctrine of Hitler and Nietzsche in the realm of finance. That is, there must be no restriction on the absolute "freedom of the will of the powerful." This doctrine holds that the moneyed oligarchy must be freed from the problems posed by the existence of modern nation-states and elected governments, such as laws about dope trafficking and money laundering, bank reserve laws, and securities laws. National governments that resist the will of the International Monetary Fund are to be crushed, their nationalist leaders overthrown or assassinated.

Von Mises is a bit more quaint—his name is associated primarily with the point of view of the Southern Confederacy of 1861-1865, the "freedom" to own slaves and to break up the American Union.

Britain's Mont Pelerin Society organized an interconnected group of institutions operating as foreign agencies within the United States, including the Heritage Foundation, the Cato Institute, the American Legislative Exchange Council, the National Taxpayers Union, and so on. This British complex guides the congressional "conservative revolutionaries" toward crushing the poor and simultaneously breaking U.S. national power. For example, the insane "Green Scissors Report," issued jointly by the National Taxpayers Union and the Friends of the Earth, demands an end to most U.S. national scientific and infrastructure programs.

When an American patriot sees von Hayek's portrait on an office wall, it ought to jolt him into a remembrance of the international nuclear power development and bold space program that John Kennedy and American nationalists fought for not so long ago.

• **Margaret Thatcher "revived the British economy."**

Anyone who that claims this ought to be sentenced to a long holiday in some formerly industrial English town, in the company of Satanic rock stars or drunken soccer fans!

• **"The idea behind the Homestead Act . . . was . . . that the federal government has a trust obligation to dispose of public lands."**

This is the saddest response. From the middle 1700s until the 1930s, the bitter contest between the Americans and the British in effect defined world politics. Abraham Lincoln and his allies, the classical republicans and nationalists, understand the issues of good versus evil as centering on the industrial development of the United States and other sovereign nations against the feudalism, imperialism, and racialism promoted by the British Empire.

But a post-World War II generation has grown up with an essentially *neutral* conception of the United States of America. The universal character of the American Revolution as a project embodying mankind's hopes against the plundering British Empire, and America's unique, humanistic mission has been denied, or ignored. If Lincoln's motives conflict with the currently chic pro-Confederate or pro-imperial viewpoints, why bother even thinking about Lincoln's ideas?

The Homestead Act had been vetoed by the previous President, James Buchanan, a strict "laissez faire" man who allowed the southern slavocracy to dominate national affairs. Free land for family farms was one of the many measures through which President Lincoln and his congressional allies secured America's agro-industrial development. Among the other measures were free colleges, federally sponsored railroads, subsidies for mining and other enterprises, a new science-for-farmers agency called the Agriculture Department, record high tariffs to start up an American steel industry, and an immigration strategy to thickly populate the American West.

Getting back to Lincoln's orientation is now a matter of national survival. Yes, it is difficult, not to say dangerous, to violate the rules of public discourse imposed by the British oligarchy and their sycophants. This can be illustrated by the following remarks, taken from the preface to the *Encyclopaedia Britannica*'s *Book of the Year 1964,* gloating over the murder of President John F. Kennedy a few months earlier:

"And yet even this monstrous killing somehow pointed to a kind of beginning or at the least, a renewal, of sensibility among Kennedy's countrymen and among the United States and other nations. The event certainly gave evidence that—like it or not—the world community was in fact a reality. The nations had become too tightly intermeshed and interdependent through both military and mercantile treaties; too many of the educated people of the world crossed international frontiers too often and accomodated themselves too easily in foreign lands to have any lingering intellectual response to 19th century nationalism, though an emotional residue persisted and was still exploited in some areas of the world."

Suggested Reading

On British sponsorship of Hitler, see Webster G. Tarpley and Anton Chaitkin, 1992, *George Bush: The Unauthorized Biography* (Washington D.C., Executive Intelligence Review).

On Pinchot, Roosevelt, and "wise use," see "How Environmentalism Killed the American Frontier," a chapter from Chaitkin's out-of-print book *Treason in America—From Aaron Burr to Averell Harriman* (New York: New Benjamin Franklin House, 1985). A copy of the chapter is available from *21st Century* for a shipping and handling charge of $2.00.

On Hayek and the Conservative Revolution, see "Phil Gramm's 'Conservative Revolution in America,' " a 56-page special offprint from *Executive Intelligence Review,* February 1995 (available at $10 from EIR, P.O. Box 17390, Washington, D.C. 20041).

Attack on Lord Rees-Mogg Unwarranted

To the Editor:

After reviewing the Summer 1995 issue, I must insist that my subscription be terminated at once. Your completely unwarranted and ignorant attack on Lord Rees-Mogg (what place does that have in a "science" publication?) has pushed my misgivings way past the limit. You seem to view British the way the Nazis viewed the Jews. Well, the Brits have their problems to be sure and the Royal Family is a sick joke, but please, get real, people. . . .

And check this out: There is far more evidence of government complicity in murder at Waco than there is for cold fusion.

John L. Quel
Bellevue, Wash.

The Editor Replies

There is indeed evidence of judicial misconduct at Waco on the part of the permanent bureaucracy at the Department of Justice—in particular, Deputy Assistant Attorney General Mark Richard and Senior Deputy John C. Keeney in the Department of Justice Criminal Division. For details, we recommend "The Long Overdue Cleanup of the Justice Department," a 32-page report in July 1995, published by Executive Intelligence Review.

In Defense of Duesberg

To the Editor:

Contrary to the assertions of Wolfgang Lillge in "The Big Lie About AIDS" in the Summer 1995 issue [p. 45], Peter Duesberg strikes me as one of the few genuine scientists left who are pointing simply to what the facts seem to be trying to say.

The space devoted to establishing that a correlation exists between HIV and AIDS was largely irrelevant because Duesberg has never denied it. In fact, correlations exist within the risk groups to all kinds of other viruses too, most of them harmless, and in some cases with correlations higher than for HIV. When everything that's going gets passed around, it becomes a marker of a risk category, but not necessarily the cause of people having that category's health problems.

The question of whether HIV is the common cause of the various sicknesses—totally different in different parts of the world, affecting completely different groups of people with different patterns of epidemiology—that are being lumped together and called "AIDS," is a purely scientific matter. To judge its truth or otherwise on the basis of perceived social and political consequences, as characterizes the regular attacks on Duesberg, is absurd.

As far as I am aware, the HIV theory has failed dismally in every one of its predictions, whereas Duesberg's has been strikingly successful. The question of what public policy ought to be is a separate issue—and where politics, moralizing, and personal prejudices have a place. Confusion of the science with the politics seems to be the root of the whole problem surrounding the subject.

The irony is the parallelism of Duesberg's position to so many of *21st Century*'s own in such other areas as ozone depletion and global warming. In its thrust, the article could be a model for virtually any of the politically correct media dismissals of Rogelio Maduro [author of *21st Century*'s book, *The Holes in the Ozone Scare*].

Perhaps one reason why the environmentalist lobby prevails is that they at least have the political sense to keep a united front. Scientists as a class seem less smart—too often eager to join in the persecutions of each other, but failing to realize that the war is against them all. It evokes the quotation that begins, "They came for the communists. I wasn't a communist, so I didn't complain. . . ."

Perhaps what we need is a constitutional amendment separating science from the state.

James Hogan
Pensacola, Florida

The American colonists had no trouble understanding how Britain intended to destroy the new Union.

The Author Replies: We Need a Commitment To Eradicate AIDS

James P. Hogan takes an interesting position in the controversy around Peter Duesberg's controversial assertions concerning AIDS. Solving the problems of established AIDS research by proposing to completely separate science from issues of state policy will not work, however, because both science and the health policy of the state have been corrupted. There cannot be any separation of public policy from personal morality, as Hogan implies.

Rather, what we need is a clear-cut commitment to eradicate AIDS—and for that matter HIV—which must be a collaborative effort of both science and policy. What seems to be forgotten is the fact that mankind has been able to cope with deadly diseases in a very effective manner when scientific principles of disease control have been applied, even in cases where the infective agent was not known.

Therefore, in the case of AIDS, why do we wait to implement effective control measures worldwide to stop the pan-

Continued on page 10

NEWS BRIEFS

NASA

Shuttle astronaut Dr. Bonnie Dunbar greets Mir 18 flight engineer Gennady Strekalov. Behind (left) is Mir 19 flight engineer Nikolai Budarin and (right) Shuttle Commander Robert Gibson.

SHUTTLE/MIR LINK-UP OPENS NEW CHAPTER IN SPACE OPERATIONS

The historic docking of the Space Shuttle Atlantis and the Russian space station Mir on June 29 is the first of seven missions planned to conduct joint operations in space. Unlike the Apollo/Soyuz handshake in space 20 years ago, the goal of these joint missions is to lay the basis for the construction and operation of an international space station at the end of this century, along with the European Space Agency, Japan, and Canada.

The masterful piloting of Shuttle Commander Robert "Hoot" Gibson made a series of complex rendezvous and docking maneuvers look exquisitely simple. The "cosmic ballet," in which the Shuttle, Mir, and the small Russian Soyuz return spacecraft were all involved during the undocking five days later, capped a perfect mission.

Astronaut medical specialists Bonnie Dunbar and Ellen Baker used the equipment aboard the Shuttle's Spacelab laboratory to do physiological studies on the three crew members, including American Norm Thagard, who had been aboard the Mir station for 110 days. The results will help determine if there are any long-term effects of the body's adjustment to microgravity, that could set a limit on the time an astronaut can spend in space.

'APOLLO 13' MOVIE: AMERICANS AGAIN LOOK UP TO THE STARS

The film "Apollo 13" captivated millions of movie-goers this summer and heightened Americans' interest in the nation's space efforts, including at the White House. Apollo 13 Commander James Lovell received the ninth Congressional Space Medal of Honor from President Clinton in a White House ceremony June 26. The President referred to the "Apollo 13" film, noting that flight director Gene Kranz tells the engineers in Mission Control that "failure is not an option." These words "have meaning far beyond that one extraordinary mission," Clinton said. "In many ways, they have become, for millions of Americans seeing that movie, a statement of the national purpose we all need as we move toward a new century and a new uncharted time here on Earth."

FEDERAL COURT OF APPEALS BLOCKS MT. GRAHAM BINOCULAR TELESCOPE

The Ninth U.S. Circuit Court of Appeals Aug. 11 denied the last option for appeal of a July 1994 lower court decision against the University of Arizona and U.S. Forest Service over the Large Binocular Telescope. It requires further years of environmental studies before the Large Binocular Telescope can be built on Mt. Graham in Arizona. At issue was whether the site could be shifted 500 yards for better observing. The University believed it was within its mandate to shift the site and began cutting trees there when 18 green groups obtained an injunction. There is now also a legal obstacle to simply returning to the old site. Federal legislation may now be sought to provide access to the new site.

Purely by Choice: SteriGenics' lineup of irradiated spices.

FOOD IRRADIATION: SPICES MEET WITH CONSUMER APPROVAL

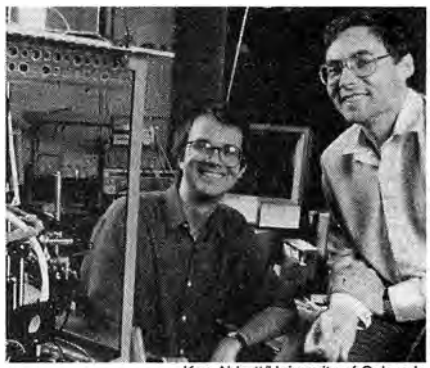
A small test marketing of 10 different irradiated spices at a California gourmet market again proved that most consumers appreciate quality products and don't believe the lies of the scaremongers. Gamma irradiation safely reduces or eliminates existing bacteria and other organisms that are common to many earth-grown foods and imported spices, and does not alter their taste or smell. When the benefits of gamma irradiation were explained and people could see and smell the freshness of the irradiated product on hot garlic bread, they bought the spices. SteriGenics, based in Tustin, Calif., packaged a variety of spices and herbs, including basil, black peppercorns, cinnamon, garlic powder, paprika, oregano, and tyme, under the label "Purely by Choice." The company has been irradiating spices for commercial food processors for 9 years, and business has increased each year by 60 to 70 percent. This was SteriGenics' first retail market test.

NEW FORM OF MATTER CREATED AT RECORD LOW TEMPERATURES

Scientists Eric Cornell and Carl Wieman announced July 13 that they had cooled rubidium atoms to 170 nanokelvin (170 billionths of a degree above absolute zero) and condensed them into a new state of matter—a Bose-Einstein condensate. At such low temperatures, the rubidium atoms are nearly motionless and condense into a "superatom," which behaves as a single entity. The quantum-mechanical waves that describe each atom spread out and merge until the entire condensate is in the same quantum state.

The condensate takes its name from the scientists who predicted its existence 70 years ago: Indian physicist Satyendra Nath Bose and Albert Einstein. Cornell and Wieman are at JILA, the Joint Institute for Laboratory Astrophysics, which is jointly run by the National Institute of Standards and Technology and the University of Colorado at Boulder.

This phenomenally low temperature is achieved by first cooling and trapping rubidium atoms in beams of laser light (see article, p. 54). After the atoms are cooled to 10 microkelvin, they are placed in a magnetic trap for further cooling, by allowing the hottest atoms to "boil out." This work "will provide physicists with a new way of studying quantum effects on a large scale, similar to the threshold effects observed in superconductivity and superfluidity," Wieman commented.



Ken Abbott/University of Colorado

Eric Cornell (left) and Carl Wieman with the apparatus used to achieve the Bose-Einstein condensation.

THE FINANCIAL TIMES OF LONDON PROMOTES CANNIBALISM

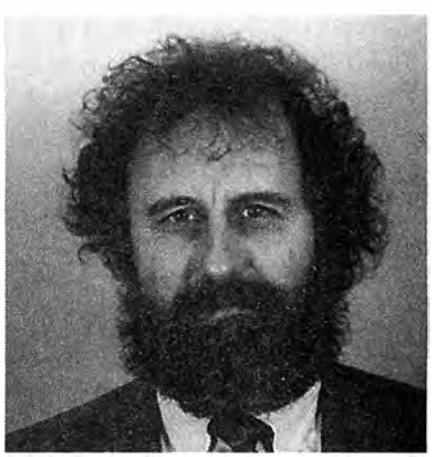
Cannibalism is a "radical but realistic solution to the problem of overpopulation" and "headhunting can be seen as good ecology" argues a two-page article in the July 15 weekend edition of *The Financial Times,* a City of London daily. Under the headline "The Case for Cannibalism," author Lyall Watson, an anthropologist, promotes the cannibalistic practices of the Asmat tribe of Indonesian New Guinea. Asmat means "the human beings," he says, while all outsiders are known as Mandowe, "the edible ones." Watson describes headhunting as "good ecology, because it reduces competition on the hunting and fishing grounds." But, Watson says, the Asmat practice of headhunting "has nothing to do with war. It is the formal and ritual expression of a need to keep things in balance. It is an Asmat admission of human responsibility for human destiny. . . . Whatever you may feel about it taking place, you have to admit that it works."

OZONE BILL STILL ALIVE; CONSTITUENTS MUST DO SOME KICKING!

Rep. John T. Doolittle, a California Republican, intends to introduce into Congress in September a bill to roll back the ban on freon. At press time, Doolittle's proposal is to push the date of the CFC ban back to the year 2000, and hold hearings on the science in order to make a decision based on reality instead of environmentalist ideology. Doolittle and your elected officials need to hear from constituents on this issue. Phone him at (202) 225-2511 or fax him at (202) 225-5444.

OZONE HOLE THEORIST WATSON GETS SOME ELEMENTARY EDUCATION

When Dr. Robert Watson, former head of the Ozone Trends Panel that launched the ozone hoax, appealed to scientists at the spring meeting of the American Geophysical Union to fight the budget cuts and attacks on environmental science, he met with an unexpected response: The June 1 audience sharply challenged Watson's definition of "good science." Watson, now Associate Director for the Environment at the White House Office of Science and Technology Policy, said that good science is what caused the banning of DDT and CFCs, and he effusively praised Rachel Carson. On both issues, Watson's "bad science" was clobbered. Not one scientist present defended Watson.



What do Watson and Rachel Carson have in common? Bad science.

Letters

Continued from page 7

demic, even if we have not clarified all the details of HIV microbiology? It seems to me that the political interests that control public health policy internationally are the same that also control AIDS research and have led it into a dead end.

However, it must be stressed again, as I did in my article, that the alternative to this dismal situation cannot be to simply deny any role of HIV in the disease process. We cannot deny that there is a worldwide AIDS pandemic with millions of victims, and that HIV plays a major role in that. Without any doubt, there is an infectious agent involved in AIDS transmission.

Today's so-called scientific establishment, because of its ideological-reductionist blindness, has failed so far to come up with novel approaches to uncover the intricate activity of retroviruses like HIV. Also the role of cofactors of AIDS and other contributing elements have been criminally neglected.

Hogan's call for a united front of scientists is a very good idea. The major role of such a united front must be to come up with a solution for the AIDS problem, with a positive alternative to the blindness of the AIDS establishment. And such a united front must mobilize for effective public health measures to stop the AIDS pandemic even before a cure and/or vaccine has been found. It is exactly such a commitment that is lacking in Duesberg's attitude.

Jeers and Cheers From Abroad

To the Editor:

I recently picked up a copy of your magazine, intrigued by the title and topics shown on the cover. While I appreciate any factual presentation which provides another perspective on the world, I soon became alarmed, not enlightened, reading your magazine.

Worse than ignorance, there is real perversity in the kind of "science" you promote. I truly hope the 21st century has nothing to do with the world you are trying to promote.

Robert Champion
Mamer, Luxembourg

To the Editor:

I think your magazine is marvelous. I read many articles with which I completely agreed (such as on nuclear power, radiation, ozone, and toxins), two with which I completely disagreed (Carol Hugunin's attack on Darwin and Carol White's attack on the British royal family) and a number which simply presented new and very interesting views (such as Carol White's "Great Atom Bomb Hoax").

Above all I welcome an abundance of scientific information that is either ignored or suppressed by the politically correct establishment.

Wonderful stuff. Keep it up.

A.R. Kenny
Rondebosch, South Africa

Coming in

21st CENTURY

- **Riemann's Philosophical Diary — First English Translation**
- **Celebrating 400 Years of Kepler's Mysterium Cosmographicum**
- **Darwin: Pro and Con**
- **How Eratosthenes Measured the Unseen**
- **The Delaney Clause: A Weapon Against Food Production**

RED SPRITES AND BLUE JETS

Unusual Lightning Flashes In the Upper Atmosphere

by Mark Wilsey

Geophysical Institute, University of Alaska

Lightning is a very dynamic and familiar example of the power of nature: It can be both frightening and fascinating. Since the time when Benjamin Franklin flew a kite during a thunderstorm to show that it was an electrical phenomenon, lightning has been studied extensively. And although scientists know a great deal about lightning, there is still much that is unknown. For example, the mechanism by which clouds become electrically charged is still not fully understood.

In recent years, new discoveries have added more puzzlement to the phenomenon of atmospheric electricity. While the brilliant, jagged bolt of lightning streaking from cloud to ground is familiar, what was unexpected is the degree of electrical activity above the clouds in the immense region between the cloud tops and the upper atmosphere.

The upper atmosphere was once thought to be a very stable and benign area, with little water vapor or weather activity present. Until recently, it was also assumed that there was no electrical activity. But two years ago, Eugene Wescott and Davis Sentman of the Geophysical Institute at the University of Alaska in Fairbanks reported unusual flashes of light reaching 80 to 90 kilometers in the upper atmosphere above thunderstorms.

These flashes, extending from the cloud tops into the upper atmosphere, occurred during a severe summer thunderstorm in the Midwest. On July 8, 1993, flying alongside a line of thunderstorms over Kansas, Iowa, and Nebraska, the researchers recorded 19 examples of light flashes with a low-light-level, black-and-white video camera aboard NASA's DC-8 Airborne Laboratory.

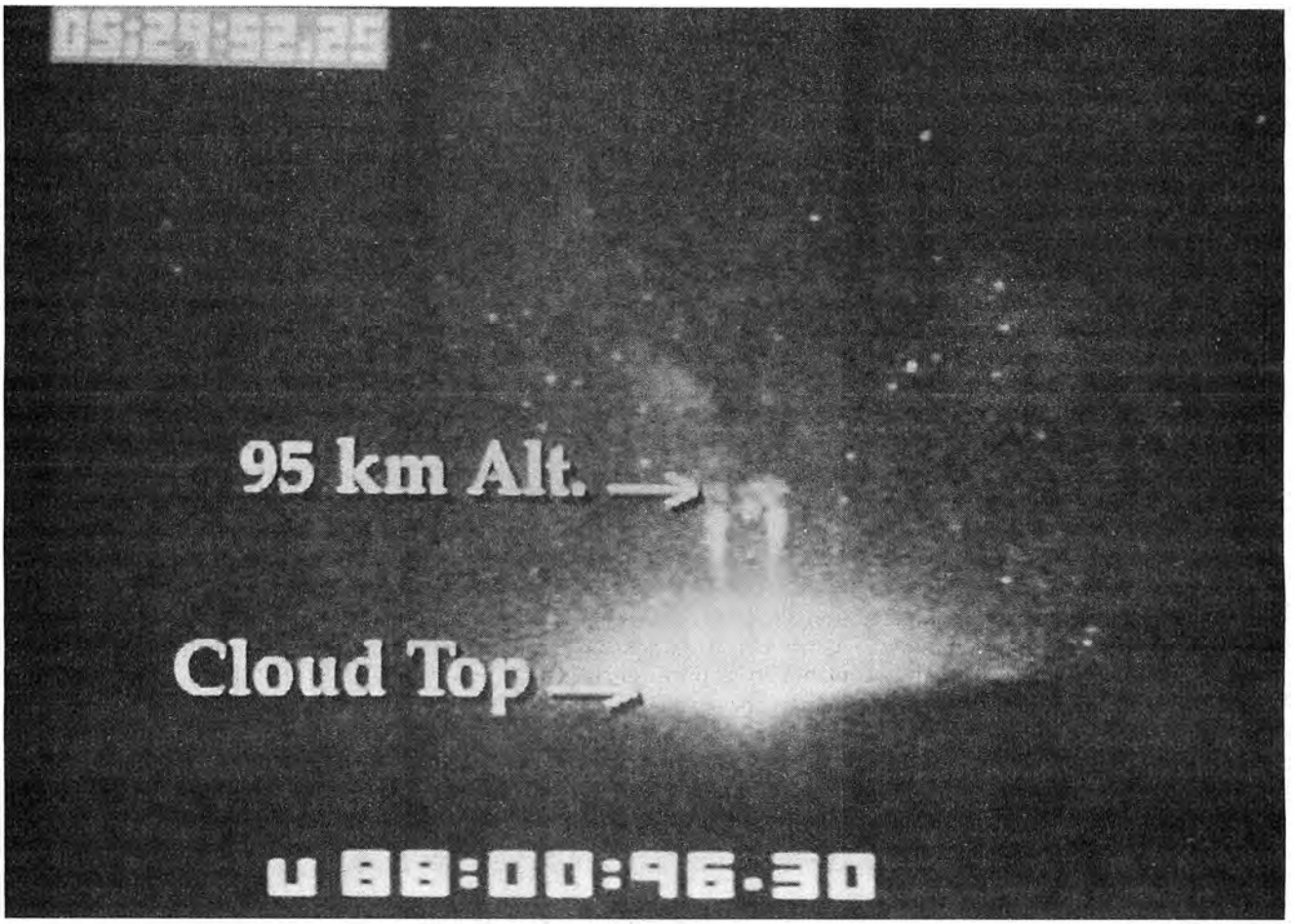
40 Km High!

The most startling feature was the size of these flashes, estimated to be about 40 km high and 10 km wide.

▲*Television image of a blue jet over eastern Arkansas, June 30, 1994. Although these jets have been sighted in the past, this one was among the first to be caught with a camera.*

Wescott and Sentman did not get very good resolution in the 1993 photos; the images on the video were ghostly and fuzzy. But even these results were tantalizing enough to pursue, and the two scientists made plans to look for flashes the next year with the best instruments available.

In the summer of 1994, Wescott and Sentman used two aircraft, each with Global Positioning System equipment, to locate the aircraft accurately. All the cameras were precisely synchronized so that the image sequences started at the same time. With these improved cameras and two aircraft, they were able to improve the resolution by a factor of 4 over the previous year.



Geophysical Institute, University of Alaska

A family of sprites over the Midwest, taken July 6, 1994. By using triangulation from two aircraft the height of the sprites was determined to be 95 km. The cloud tops are at an altitude of 13 km.

The researchers also added a very-low-light-level color camera to their equipment, which produced the first quantitative color data on the flashes. They discovered that the sprites—as they now called them—were essentially red, with very little green and blue.

Having two aircraft allowed them to triangulate to get accurate locations for the sprites. They could also determine their altitude. They were found to extend from an altitude of about 95 km down to 30 or 40 km, where the flash from the lightning washes them out. Presumably, however, the sprites connect with the top of the storm cloud.

With better photos, Wescott and Sentman could begin to identify certain structural characteristics of what they called a classic sprite. The main body of a sprite, sometimes called the head, has an irregular, semispheroidal shape. Extending below the head and down toward the cloud tops are numerous streamer-like features called tendrils. They also found that at times several sprites appear together in close proximity.

The researchers recorded more than 500 sprites in several nights of flying over Oklahoma and the surrounding states. Using low-light-level photometers, they were able to determine that some of the sprites lasted only about 3 or 4 milliseconds. In general, the sprites seemed to be associated with positive cloud-to-ground lightning strokes.

Blue Jets

During this 1994 sprite campaign, Wescott and Sentman made an unexpected discovery: They found another phenomenon, quite different from the red sprites, that started at the clouds and jetted upward at about 100 kilometers per second, or around mach 300. They called these blue jets. In one storm over Arkansas they sighted some 56 of these amazing events in less than half an hour.

The blue jets form a fairly narrow cone, averaging about 15 degrees, and they ascend from the cloud tops to about 40 or 50 km altitude. They are very energetic and last for about 200 to 300 milliseconds. It is thought that the blue color may be the result of emissions from atmospheric nitrogen ions.

The blue jets present something of a unique puzzle. They are different in nature from the sprites and do not appear to be related to them. If they are not actual movements of matter, they could be thought of as vertical fountains of light. Or they could be caused by a flow of high-energy electrons with speeds of some appreciable fraction of the speed of light. Neither seems possible, since the jets propagate too slowly.

On the other hand, if there is matter moving at mach 300, one would expect to see a shock wave. In some instances, a faint shock front may have been observed, but such a phenomenon would produce light only in the region of the

front, not along the entire length of the jet, as is observed.

Because the blue jets go up to an altitude of only about 40 to 50 km, they may be a danger to high-flying aircraft, but how dangerous is not known. The blue jets carry a lot of energy and, traveling at 100 km/sec, would be hard to avoid. They could represent a radiation hazard should one of them hit an airplane, bombarding it with relativistic electrons that could produce X-rays or other radiation.

Other Observations of Flashes

There have been numerous sightings by airline pilots and other sky-watchers of momentary flashes above thunderstorm clouds. These rare sightings have been generally ignored by scientists because they were undocumented.

Wescott and Sentman may not have been the first to see blue jets. A possible precursor observation was made in summer 1993 by pilots flying just south of Panama. After large discharges of lightning, they reported seeing "a vertical shaft of blue light that propagated from the top of the cloud upward to 100,000 feet." This description fits well that of the blue jets observed by Wescott and Sentman last year.

In 1989, John Winckler and his associates at the University of Minnesota happened to record on video unusual illuminations above a thunderstorm with a ground-based television camera. They described the image of the discharge as resembling "two jets or fountains."

Last summer, Winckler and his colleague, Walter Lyons of the atmospheric research company ASTeR Inc. in Ft. Collins, Colo., set up telescopic TV photometers on Yucca Ridge near Ft. Collins. From this point, they could survey thunderstorms across the plains as far away as 1,000 km. During their observations, which took place in the same time frame as the Wescott and Sentman sprites campaign, they captured hundreds of sprites, many of which were correlated with the airborne observations.

Other upper atmospheric flashes have been identified by Otha Vaughan at NASA's Marshall Space Flight Center in Huntsville, Ala. After searching through video recordings of thunderstorm activity made by the Mesoscale Lightning Experiment (MLE) during several Space Shuttle missions, Vaughan has been able to identify dozens of examples of upward-propagating lightning.

Are there sprites in other areas of the world? Earlier this year, Wescott and Sentman went to Peru to sample tropical thunderstorms in search of sprites, which previously had been recorded only over the U.S. Midwest. They were able to confirm that indeed sprites can be found in the lower latitudes. In eight nights of flights, the researchers spotted about 20 sprites. These South American sprites resembled their North American cousins in shape, color, and size.

With the various successful recordings of these red sprites and blue jets, other scientists have taken a second look at their own unusual observations.

Gamma-Ray Flashes

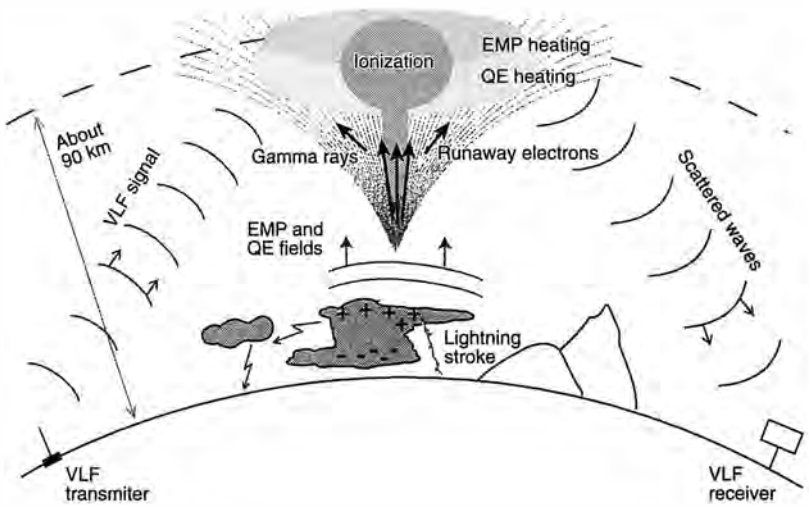
Shortly after its launch in April 1991, the Compton Gamma Ray Observatory (CGRO) began detecting intense, brief flashes of gamma rays coming from our planet—a surprise, since CGRO's mission has been to search for gamma-ray sources in space, and Earth had not been a suspected source for these flashes.

One of the instruments CGRO carries is called the Burst and Transient Source Experiment (BATSE). It is designed to survey the entire sky for gamma-ray sources, and has discovered hundreds of gamma-ray sources in the heavens, and also a dozen or so on Earth.

Gerald Fishman of the Space Science Laboratory at NASA's Marshall Space Flight Center in Huntsville, Ala., is the principal investigator for the BATSE instrument. Fishman explains that these terrestrial events had not been reported previously because it was not clear that they were real events. However, when he heard of the work of Wescott and Sentman in 1993, he took the gamma-ray flashes more seriously and published his findings last year.

The researchers at Marshall surmise that the gamma-ray flashes they detected were produced in the upper atmosphere, not below an altitude of 30 km. Flashes produced at any lower altitude would be absorbed by the atmosphere and would not reach BATSE's orbiting detectors, they say.

CGRO's orbit puts it over the Tropics and not above the Great Plains, where most of the sprites have been reported. It does not have the resolution to pinpoint



BIRTH OF RED SPRITES ACCORDING TO STANFORD'S QE MODEL

Scientists at Stanford University have developed the quasi-electrostatic (QE) model to account for red sprites. A lightning stroke triggers changes in the electric fields above the thunderstorm. These fields—as well as the lightning-induced electromagnetic pulse (EMP) itself—cause ionization and heating in the ionosphere. A stream of 'runaway' electrons could produce the observed gamma rays. Changes in the ionosphere are detected by means of changes in a VLF radio signal reflected from the ionosphere.

Source: Umran Inan, Stanford University

the gamma-ray flashes, but where weather satellite data are available, large storm systems can be seen in the areas in which the gamma-ray flashes occur.

"What we really need here is a smoking gun," Fishman explains. "That is, the observation of a gamma-ray flash at the same time they see one of these upward-going jets or sprites above a thunderstorm region." Such paired observations would tie the two mechanisms to each other.

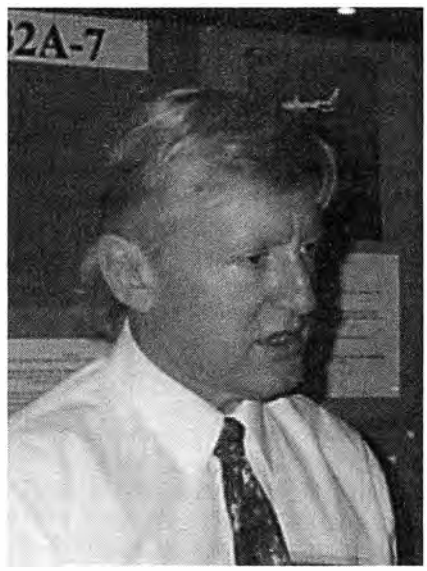
At the fall 1994 meeting of the American Geophysical Union in San Francisco, there were several papers relating to upper atmospheric lightning, many of which were presented by researchers from Los Alamos National Laboratory in New Mexico. The Los Alamos researchers too have their share of puzzling data—and possible explanations of upper atmospheric lightning.

For example, William Feldman of Los Alamos has studied the data from the Army Background Experiment, ABE, a satellite instrument that surveys gamma-ray emissions from Earth. Feldman has pointed out a number of examples of "hot spots" of gamma ray activity around the globe, such as the Himalayas and Indonesia.

Unlike the CGRO, which was designed to detect gamma-ray bursts with precision time resolution, the ABE has a time resolution of only 12 seconds. Generally, however, it surveys emissions in 96 second intervals. For this reason, most of the gamma-ray "bursts" recorded by ABE resemble what are called Trimpi events. These well-known phenomena, which have been studied for many years, occur when the electromagnetic pulse from a lightning discharge induces a precipitation of relativistic electrons from the radiation belts, which then impinge on the upper atmosphere to generate gamma rays, among other things.

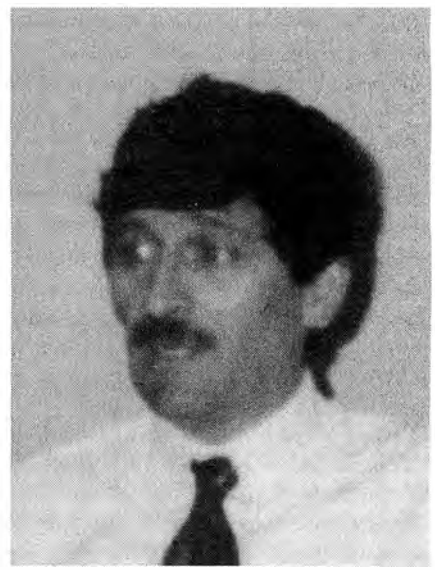
Trimpi events are more common at the higher latitudes, where Earth's magnetic field lines are closer to the surface. These events may be important as a means of discharge for the radiation belts. One could ask: What would happen on this planet if there were not as much lightning? Would the radiation belts build up to higher levels, for example?

Although most of what ABE sees are indeed Trimpi events, there also seem to be regions outside those known to be associated with the radiation belts that show enhanced gamma ray emissions, and these may be the effect of upper-atmosphere lightning directly caused by the high rate of thunderstorms in those areas.



Mark Wilsey

Davis Sentman of Geophysical Institute, University of Alaska, presents results of his recent trip to Peru in search of sprites at the spring 1995 meeting of the American Geophysical Union in Baltimore.



Mark Wilsey

Umran Inan of Stanford University presents data on changes in the ionosphere associated with red sprites at the spring 1995 meeting of the American Geophysical Union in Baltimore.

Radio-frequency Emissions

At the other end of the electromagnetic spectrum, Robert Massey and Dan Holden at Los Alamos have reported odd radio-frequency (RF) emissions coming from the Earth. These were recorded by the Blackbeard instrument aboard the ALEXIS satellite and are the most powerful transient RF emissions ever observed coming from Earth.

These emissions are very short in duration—10 microseconds—much brighter than the RF signal of ordinary lightning, and they almost always occur in pairs about 50 microseconds apart. It seems clear that they are coming from somewhere under the ionosphere on Earth because of the way they are dispersed. Because of their suspected origin, these RF emissions were dubbed Transionospheric Pulse Pairs, or TIPP events.

Why they occur in pairs is not understood. One hypothesis is that the second pulse is a reflection from the ground of a first emission, occurring at some 15 km altitude. The problem with this is that the second pulse is often brighter than the first, which may be possible under certain conditions but still does not quite jibe with all the data.

The satellite sees a large part of the Earth at one time, so resolution in pinpointing the source is a problem. Last summer, the Los Alamos researchers noticed TIPPs over the United States but did not see very many in the winter. This seasonal variation in the data would suggest that TIPPs are associated with thunderstorms.

When the thunderstorm season returns, Massey and Holden are going to look for TIPPs with two ground stations and the satellite and will try to pinpoint the locations of the sources with respect to Earth. However, as with the gamma-ray bursts, there is as yet no clear link between TIPPs and red sprites or blue jets.

Radio Experiments

Another research group, that of Umran Inan and his associates at Stanford University in California, has spent many years studying the ionosphere and the interplay between the radiation belts and the upper atmosphere. This interplay does show up in gamma-ray and X-ray bursts, Inan says, but the upward lightning phenomenon, red sprites, may have little to do with radiation belts.

Stanford has a program of radio experiments for remote sensing of the Earth's atmosphere at altitudes of about 60 to

100 km. By bouncing electromagnetic waves off the ionosphere, in this case very-low-frequency or VLF waves, the Stanford researchers can measure electrical conductivity changes in that altitude range. They are studying the physical changes in the medium.

For example, when electrons are heated, the conductivity of the ionosphere is changed and additional ionization occurs, from which the radiowaves reflect and scatter. By measuring the scattering of the signals, the researchers can map out the distribution and intensities of these ionospheric changes. In this way, they can investigate changes in the mesospheric and ionospheric density and temperature as red sprites occur.

During last summer's Sprites '94 campaign, for example, the Stanford group was able to observe several events simultaneously: A researcher in San Diego, measuring the radio signal from a large Navy transmitter in Maine, detected several events in which the amplitude of the signal changed. As it turned out, there was a one-to-one correspondence between the timing of the signal changes and that of several large sprite events. The sprites occurred right in the radio propagation pattern and the discharge into the ionosphere changed the radio pathway.

Lightning Theories

More than 70 years ago, C.T.R. Wilson theorized that it might be possible for an intense electrical field above a thunderstorm to throw a stream of "runaway" electrons into the upper atmosphere. The strength of the electrical field would go down with the square of the upward distance from its source, the thunderstorm. However, as the atmosphere becomes more rarefied with altitude, the electric potential required for a discharge that would throw up a stream of electrons decreases exponentially. This stream, unlike a lightning discharge, would continue to be accelerated by the presence of the electric field; hence the term, "runaway electrons."

Wilson concluded that eventually, with a sufficiently strong field, an altitude would be reached where a discharge would occur. Once the discharge does take place, an electric current of high-energy electrons forms, producing a conducting path between the tops of the storm clouds and the ionosphere and causing additional ionization.

Electrons accelerated over distances of several kilometers could reach very high energy levels. If such high-energy electrons are produced, they could be responsible for gamma-ray emissions by means of bremsstrahlung. Bremsstrahlung (German for braking or deceleration radiation) is emitted when high-energy electrons slam into nuclei—in this case, nuclei of molecules in the air. The electrons would have to have very high energies— on the order of 10 MeV.

The Stanford group is involved in theoretical modeling of the ways in which lightning-generated energy interacts with the mesosphere and ionosphere. One model considers the electric fields generated in the ionosphere when lightning discharges occur at cloud altitudes.

As the charge builds up in the cloud, the ionosphere and mesosphere above it respond by slowly setting up polarization charges. This occurs in the time between lightning discharges. When a lightning discharge occurs, a large part of the charge is suddenly lost and the remaining charge dictates a new electric field at ionospheric altitudes.

According to this model, the ionosphere cannot respond instantly because it is a relatively poor conducting medium. Instead, it responds slowly over the course of tens of milliseconds to the change caused by the lightning. In the meantime large electric fields exist at ionospheric altitudes. These large electric fields heat electrons and accelerate them over a short distance until they hit, for example, a molecule of nitrogen, and produce light.

The Stanford scientists call this the quasi-electrostatic (QE) heating model. The heating is thermal. The electrons are accelerated and very quickly collide with particles; then they accelerate again, then collide, and so on. This is not the same as the runaway electron mechanism.

Another type of heating occurs when the electromagnetic pulse from lightning excites electrons at high altitudes—EMP heating. The runaway mechanism may work in addition to the bulk QE and EMP heating effects to explain tendrils, the lower altitude features of the sprites. However, Stanford's Inan explains, the runaway mechanism requires substantially higher fields, so it probably occurs more rarely than the bulk QE heating mechanism, which occurs with run-of-the-mill lightning discharges.

Another theory, developed by Robert Roussel-Dupré at Los Alamos, gets around the high field requirement to produce relativistic electrons. Although Roussel-Dupré posits high electric fields from the thunderstorm to accelerate the electrons, the field may not be strong enough to initiate the discharge. Therefore, he incorporates the influx of cosmic rays into his model. The cosmic rays produce high-energy electrons, which, in effect, seed the process and lower the threshold for the discharge to occur.

What about the blue jets? "In terms of mechanism at this point we know very little," Inan said. "Whereas the red sprites come out of just basic considerations of the electrodynamics, one has to really force parameters to get anything like a blue jet."

Too Soon for Implications

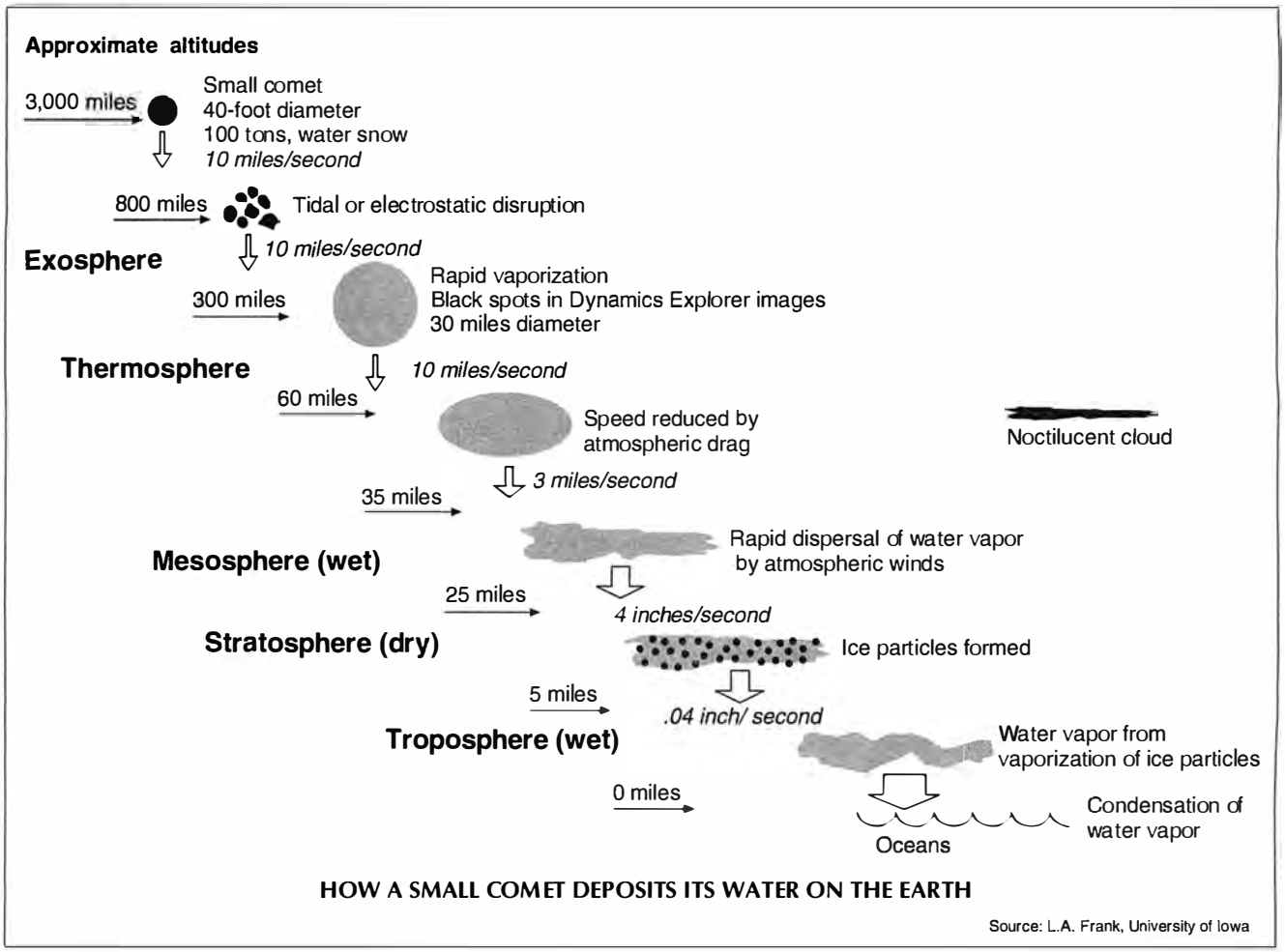
The discovery of these upper atmospheric discharges is so new that their implications have not yet been fully considered. Scientists are only now trying to sort out the electrodynamics and attempting to understand how much heating and ionization there is. Several thousand cubic kilometers of atmosphere are affected by a single discharge.

One obvious area in which these phenomena have an effect is that of atmospheric chemistry. Atmospheric chemistry is extremely complex. When the electrons are heated, the reaction rates change and potentially there will be changes in the chemistry. Because there are hundreds of reactions at different rates, all intermingled, it will take some time to evaluate the effects. Even the best models of atmospheric chemistry are far from comprehensive. To take into account upper atmospheric discharges these models may need to be overhauled or overturned. How will this affect our understanding of stratospheric ozone, for example?

The most fascinating aspect of the story is that such dramatic and large-scale phenomena as red sprites and blue jets have gone undiscovered all this time. Although they commonly occur, they were not documented until very recently. What other commonplace but as yet unnoticed phenomena occur within Earth's atmosphere as it extends out into space?

Great Heavenly Balls of Ice

by Jim Olson



HOW A SMALL COMET DEPOSITS ITS WATER ON THE EARTH

Source: L.A. Frank, University of Iowa

As advances in instrumentation continue to permit scientists to detect new phenomena in space, it is only natural that some established astronomical assumptions might have to bite the dust. This is the story of how one such new phenomenon—believed to be a large population of small ice comets vaporizing as they aproach Earth's atmosphere—stirred up a storm in the scientific community.

In April 1986, Louis A. Frank, a physicist at the University of Iowa, published two papers back-to-back in a monthly journal of the American Geophysical Union, *Geophysical Research Letters*.[1] The first paper simply announced that he and two colleagues had found thousands of anomalous "black spots" in photographic images of Earth's ultraviolet radiation, spots that represented something real in near-Earth space.

The second paper interpreted these results, hypothesizing that the black spots were images of water vapor remains of ice comets. Frank estimated that Earth was being struck by 20 of these 100-ton, house-sized iceball comets, heretofore undetected, every minute (more than 10,000,000 per year), and he suggested that this process had been occurring for eons.

Frank was well known among space scientists because of his extensive work in plasma physics and in building instruments for spacecraft going all the way back to the first U.S. lunar probes.

The two papers created a firestorm of controversy within the scientific community, particularly among geophysicists and astronomers. As Frank commented several years later in his book, "I was driving a bulldozer through dozens of the neatly planted fields of science and everyone was upset."[2]

The seeds of the controversial hypothesis had been sown several years earlier, on Aug. 3, 1981, when a Delta rocket lofted a pair of NASA satellites, Dynamics Explorer I and II, into elliptical polar orbits from Vandenberg Air Force Base in California.

Dynamics Explorer I, orbiting at altitudes varying from 350 to 14,500 miles (and carrying three instruments for which Frank was responsible), was to investigate the nonvisible light emissions

from the Earth, with the purpose of learning more about the auroral lights that appear in both hemispheres.

One of the instruments was an ultraviolet camera built and operated by Dr. John Craven, a colleague of Frank in the Department of Physics and Astronomy at the University of Iowa. This camera was to look at the Earth and record its ultraviolet emissions. The photos returned "were spectacular," in Frank's words. When either of Earth's poles was in the field of view, the photographs showed beautiful haloes (caused by the interaction between the solar wind and Earth's magnetosphere) in the upper atmosphere above the poles. In addition, Earth's day side looked like an illuminated orange ball, a phenomenon called "dayglow," resulting from the interaction of sunlight with the atomic oxygen in the upper atmosphere.

The trouble was that many of the photos of Earth had inexplicable dark spots—spots that interfered with analyzing the photos for gravity waves. Franks, Craven, and especially John Sigwarth, an undergraduate, made laborious efforts to identify the cause of the spots as "noise" from somewhere in the system. They examined the camera (remotely) for failure of its sensors and electronics, the satellite computer, the transmission systems, and the ground-based equipment, in an effort to identify the cause or causes of the photographic anomalies.

When these efforts proved unsuccessful, the scientists were led to the conclusion that the multitudinous dark spots were caused by transient, fairly fast-moving real objects in space between the orbiting camera and the Earth. They further concluded that the bodies causing the phenomenon had to be plentiful in the solar system and have the ability to absorb ultraviolet radiation within the frequency range of the UV camera.

The only candidate the Frank team of researchers could identify was the water molecule; they concluded that the dark spots were huge balls of water vapor, estimated to be 30 miles across on average. The description of the black spots and their interpretation as water vapor appeared in *Geophysical Research Letters* in April 1986.

The Tempest

Manuscripts submitted to peer-reviewed scientific journals are forwarded

University of Iowa

Frank: "I was driving a bulldozer through dozens of the neatly planted fields of science and everyone was upset."

to two or more experts (referees) in the topic discussed, who evaluate the paper and return comments to the editor. The editor, in turn, may forward the comments (with referees' names removed) to the author. Based on the comments, along with his own evaluation, the editor decides whether or not to publish.

The two referees of Frank's 1986 papers recommended against publication (one of them was highly agitated). According to Frank, the editor asked him to withdraw the second (interpretation) paper, which he refused to do. The papers were published in spite of the referees' views.

Readers' comments began to roll in, and within 15 months of publication—before the editor declared the exchange of views closed—11 comments critical of Frank's hypothesis had appeared along with Frank's replies.

Frank's 1986 papers should not have hit the geophysical community like a bolt out of the blue. Between early 1983 and 1986, he and his associates presented papers asserting that the black spots were caused by real objects at four meetings of the American Geophysical Union. (At that time, Frank had not yet arrived at the fully developed hypothesis that the objects were ice balls arriving from a region in the solar system beyond the known planets.) There was also considerable informal exchange and discussion between Frank and others in the geophysics community on the subject during those years.

Once the two papers were published in 1986, however, Frank was hit with a great deal of printed flak. Some of the comments appeared to be uninformed, some verged on viciousness, and some were patently dishonest. Most of the criticism centered on the dark spots in the imagery; the critics concluded that Frank was mistakenly assuming that spurious data represented something real.

The Big Splash

Frank answered his critics by publishing a book, *The Big Splash,* in 1990, which laid out his more-or-less fully developed hypothesis.[3] Briefly, Frank asserted that the Earth is being showered with more than 10,000,000 thirty-ton ice comets yearly, that these comets originate in the outer portion of a comet belt that lies outside the outermost planets, and that periodically an unknown planet sweeps though the region and sends cascades of small comets into the inner solar system that strike the Earth at an average rate of 20 per minute (see figure).

It should be remembered that Frank was not the first to hypothesize either an unknown outer planet or a cometary band beyond the known planets.

After Frank's book was published, the battleground shifted. In August 1991, Dr. A.J. Dessler of the Space Physics and Astronomy Department of Rice University in Houston published what he hoped would be the ultimate refutation of Frank's hypothesis in the *Review of Geophysics,* another journal of the American Geophysical Union.[4] Dessler, it should be noted, was the editor of *Geophysical Research Letters* in 1986 and the one who had initially encouraged Frank to publish his articles.

In some 28 pages, with more than 1 1/2 pages of references, Dessler did a detailed step-by-step analysis of every phase of Frank's hypothesis, concluding that it was most likely that the comets did not exist and that that the black spots in the photographs were "instrument artifacts" (that is, something old-timers might call gremlins). On the first page of Dessler's article, the editor noted that Frank was preparing a reply for a future issue.

Frank took a fairly long time to respond to Dessler's article; his reply ap-

peared in *Reviews of Geophysics* in February 1993.[5] In 28 pages, Frank replied point by point to Dessler's comments. He maintained his hypothesis that Earth is indeed being struck by staggering numbers of ice comets each year. Although he altered the estimated average size from about 100 tons to between 22 and 55 tons, this was done as a result of new information he was given by another researcher from telescopic observations of the apparent comet influx.

A Method of Proof

In an interview in May, I asked Frank what he would do, if he had everything at his disposal—finances and resources—to set up an experiment to demonstrate, once and for all, the reality of the comets. Frank, it should be noted, is still heavily involved with spacecraft instrumentation and control.

"First, he said, "I'd fly a camera above the atmosphere, because looking through the atmosphere just won't work. Actually, I believe that if the [Hubble] Space Telescope were used correctly, they'd be able to see the objects. Looking away [from Earth], if they'd just use the right exposure, and point in the right direction, they would see them as streaks . . . in visible images, just from the reflection of sunlight from them."

"What would I do?" Frank continued. "Well, I'd build an imager that was fast enough and had enough spatial resolution that I could make a movie of these atmospheric spots moving across the planet. And then I'd build another imager that could be used on the Shuttle that could look out at about 3,085 angstroms. Then you should be able to see them glowing as they go by.

"Some of these small comets would be bursts [of water vapor], and they would have these ultraviolet, not far ultraviolet, glows about them, and you should be able to see the expanding clouds from them as they whiz by the Earth. If you had a motion picture [from an unmanned satellite] even of these black spots moving across the planet in 10 frames, there's no statistical argument you'd ever make [against their reality]. If you had an imager look every 15 to 20 seconds, you would see it just march around the sky and impact into the atmosphere and see it disappear."

Almost as an afterthought, Frank added, "By the way, you may or may not know, that I am building a $14 million camera, to be launched in December on the Polar spacecraft. . . . It will do what I just described to you."

Had his articles and book provoked any response from amateur astronomers? Frank said that several amateurs had made observations based on his work. One of these amateurs, when I called him, sent me summaries of three years of night sky observation (by telescope and by unaided eye). These contained reports of a number of sightings of what he referred to as "luminous objects," which could perhaps be called circumstantial evidence of the ice comets as they enter the Earth's atmosphere and diffuse.

What's Next?

A NASA spacecraft called Polar is scheduled for launch on Dec. 8, 1995, aboard a Delta II rocket into polar orbit from Western Space and Missile Center (formerly called Vandenberg Air Force Base) in California.[6] The Polar spacecraft is part of the Global Geospace Science program, which is an ongoing effort to investigate the solar wind and the interplay between the solar wind and Earth's magnetosphere.

"If this was correct, we would have to burn half the contents of the libraries in the physical sciences."

The Polar spacecraft carries 11 instruments, each generally designed to investigate a different aspect of plasma physics. The camera referred to above by Frank is the Visible Imaging System (VIS) on board Polar. As he noted, the VIS should be capable of settling for once and for all the issue of whether the icy comets are real or merely a harebrained attempt explain away anomalous data. The camera, by the way, is not deployed for the purpose of proving Frank's hypothesis but is dedicated to other investigations; if in the process it proves the reality of the icy comets, this will be serendipitous.

And if the icy comets are proven to be real, what happens?

For those living in coastal lowlands, it's not necessary to "head for the hills." As Frank points out, if he's proven to be generally correct about the impact rate and size of icy comets, it will take around 10,000 years for the oceans to rise 1 inch.

The impact such proof will have on science, however, may be greater. As one of the referees to Frank's 1986 paper in *Geophysical Research Letters* put it: ". . . [I]f this was correct, we would have to burn half the contents of the libraries in the physical sciences."

Notes

1. L.A. Frank et al., 1986, "On the Influx of Small Comets into the Earth's Upper Atmosphere, I, Observations," *Geophysical Research Letters,* Vol. 13, No. 4, pp. 303-306 (April); and L.A. Frank et al., 1986, "On the Influx of Small Comets into the Earth's Upper Atmosphere, II, Interpretation," *Geophysical Research Letters,* Vol. 13, No. 4, pp. 307-310 (April).
2. Louis A. Frank with Patrick Huyghe, 1990. *The Big Splash* (New York: Birch Lane).
3. See note 2.
4. A.J. Dessler, 1991. "The Small-Comet Hypothesis." *Reviews of Geophysics,* Vol. 29, No. 3 (August), pp. 355-382.
5. L.A. Frank and J.B. Sigwarth, 1993. "Atmospheric Holes and Small Comets," *Reviews of Geophysics,* Vol. 30, No. 1 (February), pp. 1-28.
6. A NASA spokesman said June 1 that the scheduled launch date is still Dec. 8, 1995, but as of press time, the effect of budget cuts on the launch date is unknown.

Mary Evans Picture Library /Photo Researchers

EUREKA! Rediscovering the Method of Archimedes

Although best known as a geometer and mathematician, Archimedes was, in fact, a universal genius.

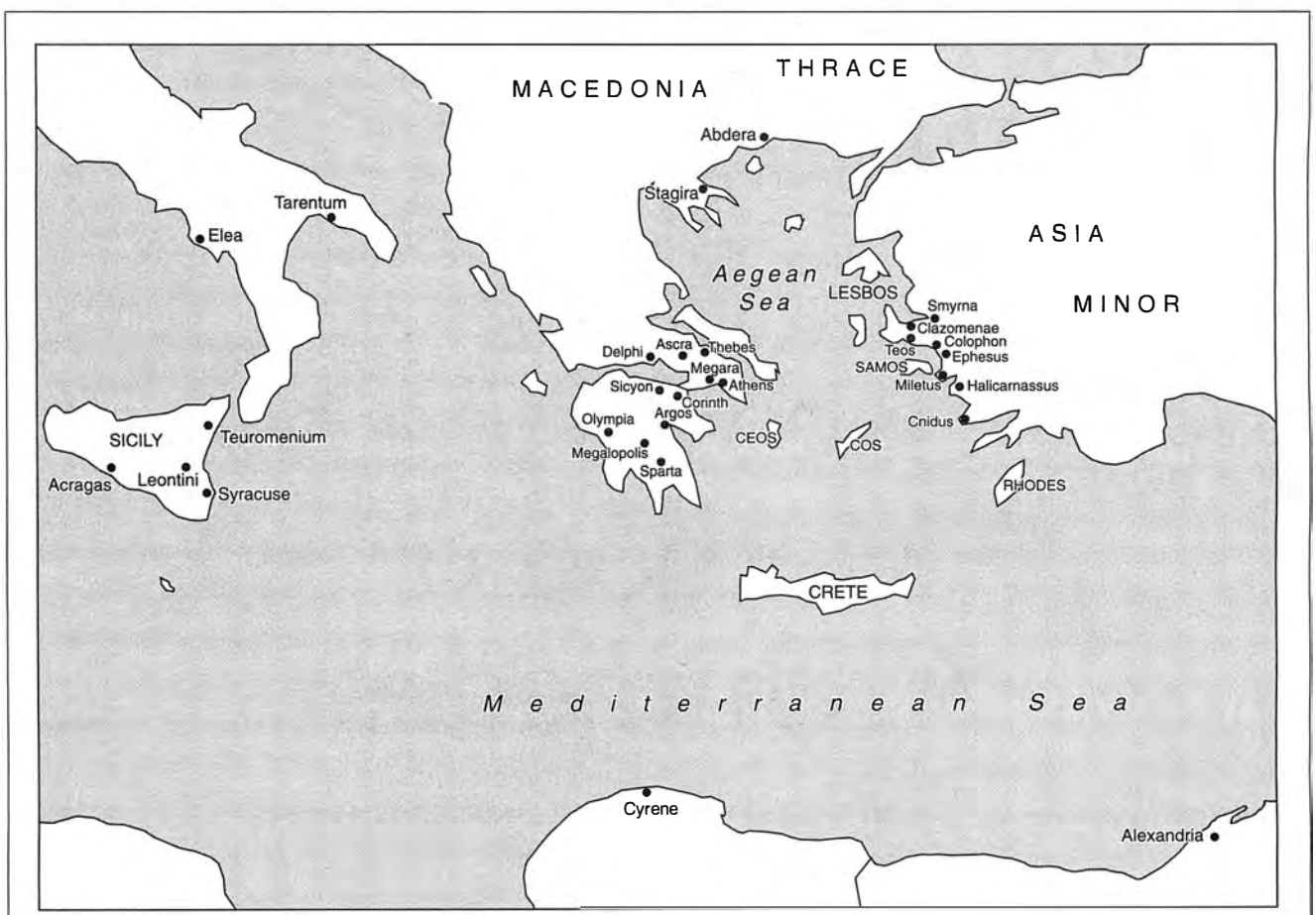
by Bob Robinson

It is a tribute to the great American poet Edgar Allen Poe that he named his beautiful, if little known, treatment of science and natural law, "Eureka," in remembrance of the great Syracusan scientist, Archimedes. Just as in a well constructed poem, Archimedes' discoveries and inventions, and the method by which he made them, are not really separable.

Archimedes lived from 287 to 212 B.C. in Syracuse, a city built in about 700 B.C. by Corinthian Greeks on the southeastern coast of Sicily. By the fifth century B.C., Syracuse had become one of the most important and strongest of the Greek cities. At its zenith, Syracuse had a population of 1 million. Its temples and monuments are, after the Parthenon, some of the most impressive Greek remains in existence.

The scientific spirit of classical Greece blossomed in the Academy of Athens, founded by Plato in 387 B.C. It was spread throughout the known world by the conquests of Alexander the Great (356 to 323 B.C.). Alexander planned and built his world capital not in his native land of Macedonia, but at the crossroads of world trade on the Nile delta in Egypt, in a city he called Alexandria. There he built a universal museum and library, eventually containing more than three quarter million "volumes" (papyrus scrolls) from Greece, India, Rome, Egypt, and elsewhere. As we shall see, Archimedes was in direct correspondence with the chief librarian in Alexandria (circa 220 B.C.), Eratosthenes, who was himself a first-rank astronomer and geometer.[1]

After the death of Alexander the Great, the classical Greek city-state, modeled on the republican constitution of Solon of Athens, was all but eclipsed by a contest between empires, and now followed the Spartan constitution of Lycurgus. By the time of Archimedes, Rome and Carthage had become—according to admittedly unreliable later Graeco-Roman historians like Plutarch—equal "superpowers" contending for domination of the Mediterranean world in the so-called Punic Wars.



MAJOR CITIES IN ANCIENT GREECE

Ultimately, when Julius Caesar conquered Egypt in 48 B.C., even the Alexandrian library—which had become the virtual nerve center of ancient intellectual life—was destroyed by fire.

In retrospect, we see that the very existence of Archimedes in the third century B.C.—and of friends of his like Eratosthenes—was the main hope for preventing the Roman Empire from causing a descent into a permanent dark age.

Although best known as a geometer and mathematician, Archimedes was, in fact, a universal genius. The rediscovery of his work, and the translations of it made by the circles around Nicholas of Cusa in 1450, were (along with Plato's dialogues) crucial for all the breakthroughs of the Golden Renaissance. The many mechanical inventions of Leonardo da Vinci, the use by Kepler of the 5 regular Platonic and 13 semiregular Archimedean solids in astronomy and crystallography, and later on, the development of the integral calculus by Pascal, Huygens, and Leibniz, all owe a great debt to Archimedes.

Archimedes' Discovery

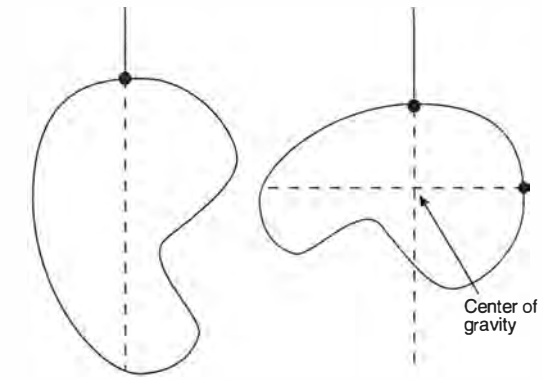
Archimedes' most fundamental scientific discovery was the concept of center of gravity and its relationship to accomplishing work. Geometrically, this concept relates to circular action, the conic sections, the spiral, and the sphere. His many inventions based on leverage and screw action are a corollary of this breakthrough.

It is important to distinguish between the use of the balance scale, in commerce, for example (which far predated Archimedes) from "center of gravity" as a universal concept of natural law. This concept is, one might say, the "center of gravity" around which all the rest of Archimedes' work revolved and the basis on which he unified geometry and physics into one coherent subject. Two of his extant works, "On the Equilibrium of Planes" and "The Method," treat the concept of center of gravity explicitly.

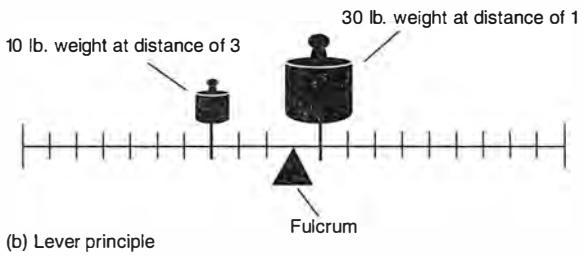
The center of gravity is a point such that, if a body be conceived to be suspended from that point, no matter what the body's initial orientation, the weight carried thereby remains at equilibrium and the body preserves its original position (Figure 1). It can also be conceived as the intersection of all the axes around which a body in free fall will rotate, no matter what its direction of rotation. Thus, another representation of the center of gravity can be "center of inertia." To have a center of gravity fixed relative to the parts of a body, the parts of the body must generally, although not always, have a fixed relationship to one another.

The center of gravity need not be within a body or in any of the objects composing the body. For example, in a torus, the center of gravity is in the hole in the middle of the torus. If two objects are in balance on opposite sides of a fulcrum, the center of gravity of the two objects, taken as a set together with the arm of the balance itself, is the point in a plane perpendicular to the balance arm that passes through the fulcrum of the balance, not in either of the objects being balanced per se. In a sphere, whether solid or hollow like a soap bubble, the center of gravity is at its center. In a regular or semiregular solid, the center of gravity will be similarly situated.

However, all bodies, no matter how dissimilar to the sphere in appearance or how asymmetric, have one and only one center of gravity. To find the center of gravity of any body



(a) Center of gravity



(b) Lever principle

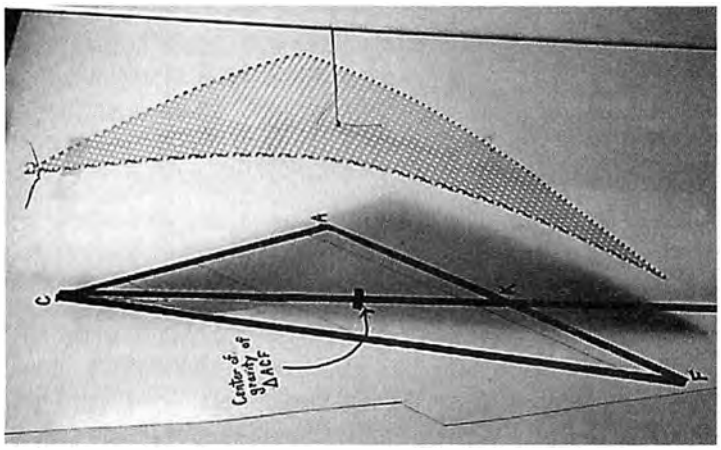
Figure 1
ARCHIMEDES' CONCEPT OF THE CENTER OF GRAVITY

Using his concept of the center of gravity and a balance, Archimedes was able to measure and compare various curvilinear surfaces, solids, and lines that were otherwise not comparable—and to make discoveries about their properties and relationships. He contrasted this method to the technique of exhaustion, which fills up volumes, areas, and lines with smaller and smaller units ad infinitum—to approximate, asymptotically, their measurement (see Figure 8). The center of gravity method involves actual equalities, not asymptotes or convergences.

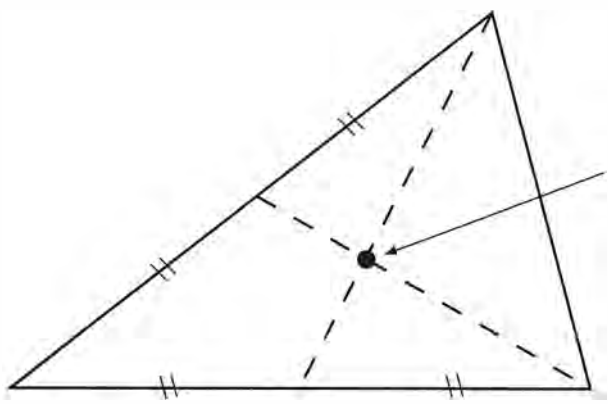
The center of gravity, which is not the center of mass, is a point such that if a body is suspended from it, the weight of the body will be at equilibrium. Using this concept, Archimedes invented many devices and methods for doing work, including his well known use of leverage and screw action.

To find the center of gravity of any body small enough to be handled, hang the body successively from two or more points on its surface (a). When it stops wobbling, the center of gravity will be found where all the lines meet that are extensions of the cords from which it is hung.

The balance shown in (b) demonstrates Archimedes' lever principle, where the product of the weight times the distance is equal on both sides. Thus, a 10-pound weight at a distance of 3 units on one side of a fulcrum will balance a 30-pound weight at a distance of only 1 unit on the other side.



(a)



(b)

Figure 2
THE CENTER OF GRAVITY OF A TRIANGLE

The center of gravity of a mesh triangle was found by suspending it such that it lies parallel to Earth's surface (a). Another way Archimedes determined the center of gravity of a triangle comes from plane geometry. Bisect the base of a triangle and fold it along the line from the bisection point to the opposite vertex, which will produce two equal triangles. Repeat this process for another side of the triangle, and the intersection of both folds will be the center of gravity of the triangle.

For two triangles equal in area, Archimedes showed that the center of gravity of the two is the midpoint of the line connecting their respective centers of gravity.

small enough to be handled, it is merely necessary to hang the body successively from two or more points on its surface. Once the body has stopped wobbling and is hanging in equilibrium, imagine the extension of the cord from which the body is hung as forming an axis of rotation running through the body, similar to the Earth's axis of rotation or that of a gyroscope. The center of gravity is the point at which all such lines meet.

The center of gravity is the *physical* center of an object. A circular object weighted to one side, such as an out-of-balance wheel, will have a visible center that is not the same as its center of gravity. The center of gravity is also different from the center of mass. On a balance, for instance, the center of gravity is in a plane passing through the fulcrum of the balance, no matter how much more weight is on one side of the balance than the other.

If a 10-pound weight were on one side of a balance and a 2-pound weight on the other, the *center of mass* would have to be in a plane dividing the 10-pound weight so that 4 of its pounds joined with the 2-pound weight to divide the total weight in half: 6 pounds and 6 pounds.

The center of gravity, on the other hand, will be in a plane (including the fulcrum of the balance) that is 5 times as close to the 10-pound weight as the 2-pound weight, but not necessarily passing through the 10-pound weight. What is being equated, or balanced, at the center of gravity is mass times distance from the center of gravity, or physical space, not mass or distance separately.

In certain cases in which materials of construction are uniform and the figure is symmetrical, the visible center, the center of gravity, and, for that matter, the center of mass all coincide. As is self-evident, these cases include figures such as a finite straight line at its midpoint, or a circle or sphere at its center of spatial extension. A square also has a fairly obvious center of gravity, which may be defined as the intersection of its diagonals. The center of gravity of a rectangle or parallelogram may be similarly defined.

What about a triangle? We can test to see from what point the triangle, when hung, is in approximate equilibrium, as shown in Figure 2. But think. If you are familiar with a little plane geometry, you may know that the area of a triangle on a flat surface is equal to one half its base times its height. So if we bisect the base of a triangle, then fold it along the line from the bisection point to the opposite vertex, we create two triangles, each with the same base and height and, therefore, with the same area.

This fold forms not the center of gravity, but an axis of gravity or an axis of inertial rotation, as previously described, similar to the axis about which a planet or a gyroscope turns. If we then bisect another side of the triangle and fold again from the new bisection point to its opposite vertex, the intersection of the first and second folds will give us a unique point that is the center of gravity of the entire original triangle. It can be easily shown that this point will always be one third the way along the median (the line produced by the fold) from each base midpoint (bisection point) to its opposite vertex. Moreover, it is the same point for all three axes of rotation, thus defining a unique center of gravity for any triangle on a plane.

Suppose now we have two triangles, adjacent or separate, but fixed relative to each other and equal in area. The center of gravity of the set of both triangles will be the midpoint of the line connecting their respective centers of gravity.

But what about a surface that cannot be neatly divided into triangles or a three-dimensional body that cannot be neatly divided into pyramids; for example, a curvilinear surface other than the circle or sphere, one which is not perfectly symmetrical? What about the conic sections other than the circle, such as the ellipse, parabola, and hyperbola? What about surfaces and volumes produced by revolution of the above figures, such as the ellipsoid and the paraboloid? What about sections of these surfaces and volumes? On the level of engineering, what about a ship that must be designed with a center of gravity that is appropriate to withstand rough seas?

These are some of the questions Archimedes answered.

The Technique of Exhaustion

One way to find the approximate area of curvilinear figures that are formed by some rule, such as the conic sections, is to divide them up into smaller and smaller triangles that approach the curve as a limit, asymptotically. This technique, developed by Eudoxus, a student of Plato who lived 150 years before Archimedes, is called, appropriately, "exhaustion," and was used successfully by Eudoxus to approximate the volumes and surface areas of cones and frustrums of cones.

Archimedes himself used this technique to define the area of the parabolic conic section, purely in terms of a series of triangles, as neither more nor less than 4/3 the area of the maximum triangle inscribable within it (Figure 4). This Archimedes called the "Quadrature of the Parabola."

Moreover, because the triangles composing the parabola are symmetrically organized around the central vertical axis of the parabola, Archimedes was able to determine the center of gravity of parabolic sections using the same technique, as he shows in his work "On the Equilibrium of Planes." In turn, this gave Archimedes the insight necessary to define (in his work "On Floating Bodies") the constraints on the shape of a ship's hull if its center of gravity were to be such that it would stay upright in the water.

However, Archimedes was never able to figure out the circle's area or circumference, as he had determined the parabolic section's area. He could find no way of relating the circular area or perimeter to the diameter of the circle or to an inscribed triangle or other inscribed polygon inside the circle, by means of any known number, whether whole, fractional, or even "incommensurable," such as the square root of 2. Nor did he claim to have done so, as some others did. Archimedes did successfully measure a circle with a spiral, but this, like Eudoxus' earlier determination of the surface area and volume of a cone in terms of its circular base and its height, already presupposes circular action.

It is a crucial paradox that while Archimedes naturally could only approximate π, a term he did not use, he could nevertheless determine the area of the circle and the surface area and volume of the sphere precisely in terms of π; that is, by treating π as a real number even though neither he (nor anyone else) could logically deduce its value from the counting numbers or a series of triangles. How did he resolve this paradox?

Archimedes' Discovery Reexamined

Let us take a step back. What about the case where the triangle or other figure is of varying density; in other words, where the figure is heavily weighted to one side, contrary perhaps to appearances? Is not such a circumstance rather the rule than the exception? In such cases we must go back to the previously mentioned method of balancing the body, or some ordered sequence of its parts, to find its center of gravity. This sort of investigation may be called, by contrast with the technique of exhaustion, the center of gravity method.

Here are a few examples of Archimedes' use of the center of gravity method.

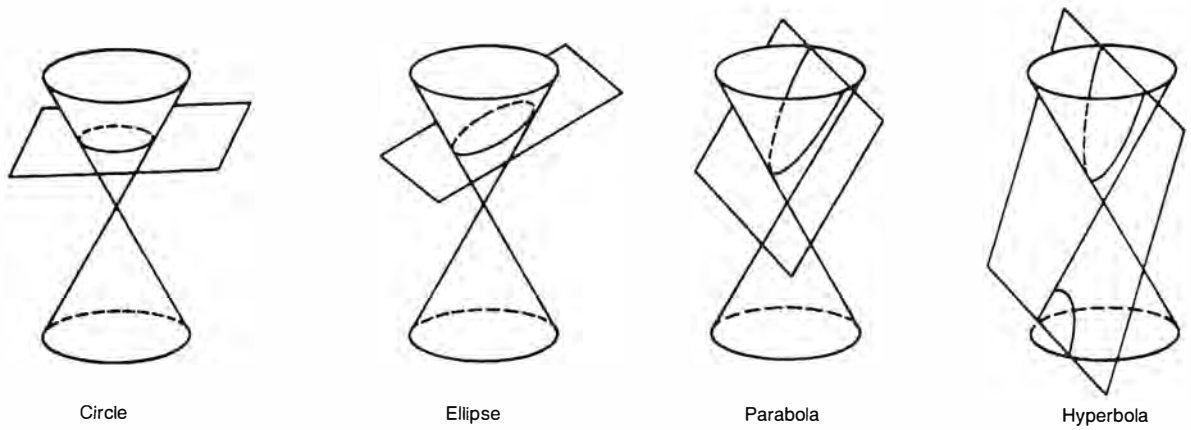


Figure 3
FINDING THE CENTER OF GRAVITY OF OTHER PLANE FIGURES

The conic sections are those figures obtained by slicing the cone with a plane. The slice may be parallel to the base of the cone (producing a circle), may cut the cone at an angle less than parallel to the slope of the cone (ellipse), parallel to the slope (parabola), or at an angle greater than parallel to the slope, thus cutting both horns of the cone (hyperbola).

To find the center of gravity or the area of regular curvilinear figures such as the conic sections, Archimedes used a technique developed by Eudoxus. He divided the figures up into smaller and smaller triangles that approached the curve of the figure as a limit.

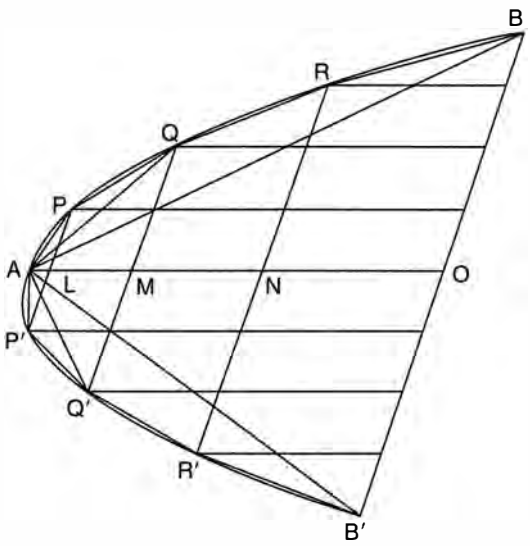


Figure 4
ARCHIMEDES' QUADRATURE OF THE PARABOLA BY EXHAUSTION

Using the technique of exhaustion, Archimedes found the area of the parabola to be neither more nor less than 4/3 the area of the maximum triangle inscribable within it. He used a series of triangles organized around the central vertical axis of the parabola.

As shown, the midpoint of the line BB′, which bounds the parabolic section, is O. Therefore, ALMNO is a median of the triangle ABB′. Lines parallel to ALMNO and passing through points Q and Q′ similarly bisect BA and AB′, and so form medians of the triangles BQA and B′Q′A, respectively. This construction of ever-smaller triangles that fill the parabola as a limit permits determination of both the area of the parabola and its center of gravity.

First, consider the famous story of King Hieron's ceremonial wreath. King Hieron of Syracuse, who was a friend of Archimedes, wanted to know if someone had substituted silver for some of the gold in a sacred wreath. Archimedes was set to the task. One day, while taking a bath, he was pondering how to make his investigation without melting the wreath down. As he descended into the bath, he noticed that his body displaced a specific amount of water, causing the water level to rise by a certain amount. As the story goes, Archimedes jumped out of the tub and went running down the streets of Syracuse stark naked crying, "Eureka!" (I have found it!).

Archimedes went to the palace and placed King Hieron's wreath on one side of a balance with an equal weight of pure gold on the other, thus balancing the two objects at equal distances. (Whether he was still naked I have no idea.) Then he substituted an equal weight of silver for the gold, again exactly balancing the wreath. Next he immersed first the gold and then the silver in a vessel of water. The silver, of course, displaced more water than the gold, silver being less dense than gold. Finally, he immersed the wreath, finding that it displaced more water than its weight in gold but less than its weight in silver, showing thereby what proportion of the gold had been replaced by silver in the wreath.

Archimedes had used the fulcrum of the balance to establish a center of gravity and equality of mass between the wreath, the gold, and the silver. He was then able to demonstrate that the volumetric displacement per unit mass is a unique characteristic of each element, such as gold or silver. This characteristic, called specific gravity, became much later the foundation stone of the development of chemistry from Lavoisier to Mendeleyev.

Now consider a second example, this time from astronomy. Archimedes wrote a beautiful piece called "The Sand Reckoner," which is comparable to Kepler's 1600 work "The Six-sided Snow-flake." Archimedes hypothesized the number of grains of sand that the universe could contain, thus giving, for his day, a sort of maximum and minimum measurement to the universe. To accomplish this, Archimedes had to develop a whole new system of exponential numbers.

Archimedes wrote to King Gelon:[2]

> . . . Now you are aware that "universe" is the name given by most astronomers to the sphere whose center is the Earth and whose radius is equal to the straight line between the center of the Earth and the center of the Sun. . . . But Aristarchus of Samos brought out a book consisting of some hypotheses, in which the premises lead to the result that the universe is many times greater than that so called. His hypotheses are that the fixed stars and the Sun remain unmoved, that the Earth revolves about the Sun in the circumference of a circle, the Sun lying in the middle of the orbit, and that the sphere of the fixed stars, situated about the same center as the Sun, is so great that the circle in which he supposes the Earth to revolve bears such a proportion to the fixed stars as the center of a sphere to its surface. Now it is easy to see that this is impossible; for since the center of a sphere has no magnitude, we cannot conceive it to bear any ratio whatever to the surface of the sphere. We must, however, take Aristarchus to mean this; since we conceive the Earth to be, as it were, the center of the universe, the ratio which the Earth bears to what we describe as the "universe" is the same as the ratio which the sphere containing the circle in which he supposes the Earth to revolve bears to the sphere of the fixed stars.

Thus, based on Aristarchus' heliocentric model of the solar system, he made an equation between two proportions, that as the diameter of the Earth is to its orbit about the Sun, so is the diameter of the Earth's orbit to the diameter of the then-accepted "sphere of the fixed stars."

Archimedes developed a spherical model of the heavenly motions, probably based on Eudoxus' earlier concentric sphere model of the universe, in which, we may conjecture, the above proportions were to be found. However, the models, along with Archimedes' treatise "On Sphere Making," were "lost" under Roman rule.

Consider the coherence of the heliocentric model of the solar system with Archimedes' concept of center of gravity. Aristarchus had shown, as a key part of his theory, that the Sun is much larger than the Earth or the Moon. Even though it

would be difficult for Archimedes to measure the density of the Sun directly (as it still would be so today), and notwithstanding the fact that the solar system is not a rigid body but has parts constantly moving relative to one another, it made perfect sense for Archimedes to hypothesize a center of gravity that would be close to the Sun, around which the Sun would revolve closely, while the planets would revolve at greater distances.

Many of Archimedes' inventions were not "lost": The Archimedean screw, or cochlea, was called by Galileo "not only marvelous but miraculous," insofar as it appears to defy gravity by pulling water uphill without compartments in the screw mechanism to keep the water from slipping back down. Archimedes apparently developed this simple mechanical device on one of his trips to Egypt in order to help irrigate land around the Nile River, but it was also used as a bilge pump for ships and mines.

There are several versions of the story of how Archimedes singlehandedly launched the ship *Syracusia,* to the amazement of King Hieron and the citizens of Syracuse, by utilizing forms of mechanical advantage, singly or in combination. Block and tackle, the windlass, the endless screw, and simple leverage all are mentioned by various authors, but in one way or another, Archimedes reduced the effort needed to move a load by proportionally increasing the total distance through which the effort was exerted.

When he had accomplished this task, Archimedes said, "Give me a place to stand, and I will move the Earth."

His other inventions included the crane, the hydraulic organ, and the parabolic reflector. According to some later accounts, perhaps apocryphal, Archimedes used a reflector with an elaborate network of small rotatable mirrors to focus sunlight and set enemy ships on fire. Leonardo da Vinci marveled at Archimedes' invention of a weapon for throwing burning pitch onto an opponent's ship. Again and again in these accounts, the same basic idea of leverage reappears: Discover the true center of gravity of a body, then rotate the body about its center of gravity in order to perform work most efficiently, given all the circumstances.

Because of this *method,* rather than any particular invention, Archimedes represented the potential in the third century B.C. for city-states to be economically sovereign and to defend themselves against empires. One is tempted to say that Archimedes developed the equivalent of a Strategic Defense Initiative (SDI) for city-states of his day, a sort of "BCI."

Given this brief account, it is now possible to situate Archimedes' defense of Syracuse, from 216 to 212 B.C. This is an episode in the annals of science as history that will forever make Archimedes come alive, even though it ended with Archimedes' own death.

When Hannibal, the great Carthaginian general, almost conquered Rome in 216 B.C. at the battle of Cannae, his strategy was to provoke a revolt of the city-states under Roman control and the Romans themselves against the Roman Empire. The strategy did not quite work, perhaps because of distrust of Hannibal and the Carthaginian army, who were, like Rome, empire builders and human sacrificers. Nevertheless, Syracuse and a few other Roman subject peoples, such as the Capuans and the Gauls, did throw off Roman rule, with the consequence that the Romans had to draft 10 percent of their population to survive.

Fabius Maximus, who had been appointed Roman dictator in this crisis, sent Marcellus, a general, out to defeat Hannibal and reconquer the cities in revolt. The great tragedy in this situation was that Hannibal did not form an open alliance with Archimedes. Such an alliance could have prevailed against the siege of Syracuse by the Romans. But the Romans won, so the histories that come down to us about Archimedes' brilliant defense of Syracuse were written by Roman historians Polybius, Livy, and Plutarch. The ostensible subject of Plutarch's account, for example, was not Archimedes, but General Marcellus. Even so, Plutarch, himself a Greek who lived under Roman rule, gives a highly moving account:[3]

> When, therefore, the Romans assaulted the walls in two places at once, fear and consternation stupefied the Syracusans, believing that nothing was able to resist that violence and those forces. But when Archimedes began to ply his engines, he at once shot against the land forces all sorts of missile weapons, and immense masses of stone that came down with incredible noise and violence; against which no man could stand; for they knocked down those upon whom they fell in heaps, breaking all their ranks and files. In the meantime huge poles thrust out from the walls over the ships sunk some by the great weights which they let down from on high on them; others they lifted up into the air by an iron hand or beak like a crane's beak. . . .
>
> A ship was frequently lifted up to a great height in the air (a dreadful thing to behold) and was rolled to and fro, and kept swinging, until the mariners were all thrown out, when at length it was dashed against the rocks, or let fall. . . . Yet Marcellus escaped unhurt, and deriding his own artificers and engineers, "What," said he, "must we give up fighting with this geometrical Briareus, who plays pitch and toss with our ships, and, with the multitude of darts which he showers at a single moment upon us, really outdoes the hundred-handed giants of mythology? . . . Marcellus desisted from conflicts and assaults, putting all his hopes in a long siege. . . .
>
> But nothing afflicted Marcellus so much as the death of Archimedes, who was then, as fate would have it, intent on working out some problem by a diagram, and having fixed his mind alike and his eyes upon the subject of his speculation, he never noticed the incursion [by subterfuge] of the Romans, nor that the city was taken. In this transport of study and contemplation, a soldier, unexpectedly coming up to him, commanded him to follow Marcellus; which he declining to do before he had worked his problem out to a demonstration, the soldier, enraged, drew his sword and ran him through. . . . Marcellus ever after regarded him that killed him as a murderer. . . .

Marcellus, who kept two of Archimedes' planetaria as booty after the conquest of Syracuse, was later ambushed and killed by Hannibal. Plutarch describes the inscription on Archimedes' tomb of a sphere inscribed in a cylinder, which was confirmed to exist centuries later by Cicero, on a trip to Syracuse. What is most clear in Plutarch's account, however,

is the awe with which the Romans, and Plutarch himself, regarded Archimedes' scientific method.

Archimedes' Method

Let's take a closer look at Archimedes' method. There is no better place to start than with a letter from Archimedes to his friend Eratosthenes, the librarian scientist at Alexandria. This letter is an introduction to a treatise Archimedes wrote called, appropriately, "The Mechanical Method," which includes numerous illustrations of Archimedes' method of solving various geometric problems that had perplexed previous geometers. The letter and the treatise were unearthed in 1906 by the German scholar J.L. Heiberg. The document had been concealed for seven centuries under an Eastern Orthodox liturgical document. The letter to Eratosthenes says, in part:[4]

> I thought fit to write out for you and explain in detail in the same book the peculiarity of a certain method, by which it will be possible for you to get a start to enable you to investigate some of the problems in mathematics by means of mechanics. This procedure is, I am persuaded, no less useful even for the proof of the theorems themselves; for certain things first became clear to me by a mechanical method, although they had to be demonstrated by geometry afterwards because their investigation by the said method did not furnish an actual demonstration. But it is of course much easier, when we have previously acquired, by the method, some knowledge of the questions, to supply the proof than it is to find it without any previous knowledge.

In this letter, Archimedes explicitly states that his method of scientific discovery is to be distinguished from his method of formal logical proof. This is a crucial indication that Archimedes' method is deliberately based on the method of hypothesis found in Plato's dialogue "Parmenides" and not on the logic of Aristotle or Euclid. That is, Archimedes would not be coerced into accepting any logical system, Roman or otherwise, if he could construct a geometric form inconsistent with the axioms of that system, yet internally coherent as a conception.

This distinction, between the scientific workshop method and the formal logical proof, is roughly correlated in Archimedes' own mind with the distinction between the "center of gravity," or use of a balance to equate various geometric forms, and the technique of exhaustion to formally prove that such equations were consistent with Pythagorean geometry. Archimedes was no formalist even here, and we shall see that what he has in mind is a kind of teamwork between the two methods: the first to achieve breakthroughs any way he could and the second to force even logical formalists to accept his results, if only grudgingly.

The center of gravity permits the direct measurement of various curvilinear surfaces, solids, and lines not otherwise comparable. It gives a sufficient reason to believe a proposition to be true. The technique of exhaustion shows that such a proposition does not contradict existing axioms, by demonstrating that any other proposition (involving quantities less than or greater than those of the original proposition) does contradict existing axioms.

To be valid, the technique of exhaustion must always involve some rule of formation of an infinite series, geometrically or numerically. The center of gravity method, although it can be of some use even as a single empirical measurement, is only rigorously scientific if, by ingenious experimental design, it can be shown to involve an ordered series of its own distinct type, as we saw in the case of the triangle. Both involve the creation, or discovery, of some underlying rule or principle. However, the technique of exhaustion ignores all differences except those of extension, while the center of gravity method is based—in the largest sense, as we have seen—on taking note of the underlying physical differences that determine visible differences. Thus, exhaustion is a technique, while the center of gravity approach is a method.

In using balances, or the center of gravity method, in the examples shown in "The Method," Archimedes assumes that all volumes, planes, lines, and points have weight (and therefore mass) and are thus measurable on a balance of some sort. Moreover, in reconstructing Archimedes' experiments, one must be careful to use materials with a characteristic width, depth, and specific gravity.

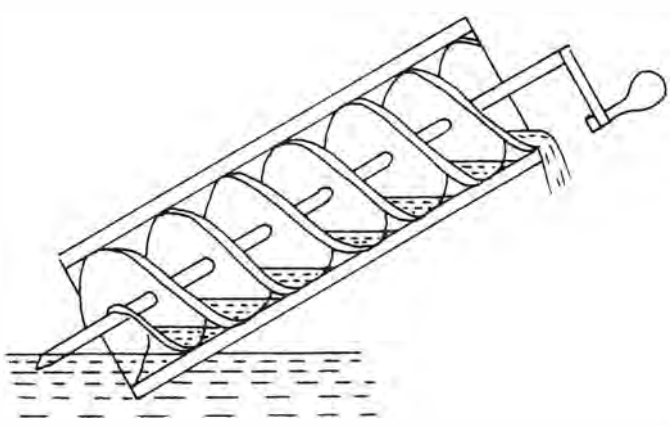


Figure 5
ARCHIMEDES' SCREW

Archimedes designed the screw or helical pump to carry water uphill; for example, to remove water from the hold of a large ship. A circular pipe encloses a helix. When it is rotated with one end in the water and at an angle of about 45 degrees to the water, the rotation causes the water to flow up. The screw has no compartments but depends on gravity.

The technique of exhaustion, on the other hand, is based on the opposite assumption; namely, that volumes, areas, and lines can be divided *ad infinitum.* For example, take the series 1/2 plus 1/4 plus 1/8. . . . There is no number less than 1 that the series cannot be shown to exceed. Therefore, we conclude indirectly, by the above *reductio ad absurdum,* that the limit of the series is 1.

The technique of exhaustion was used long before

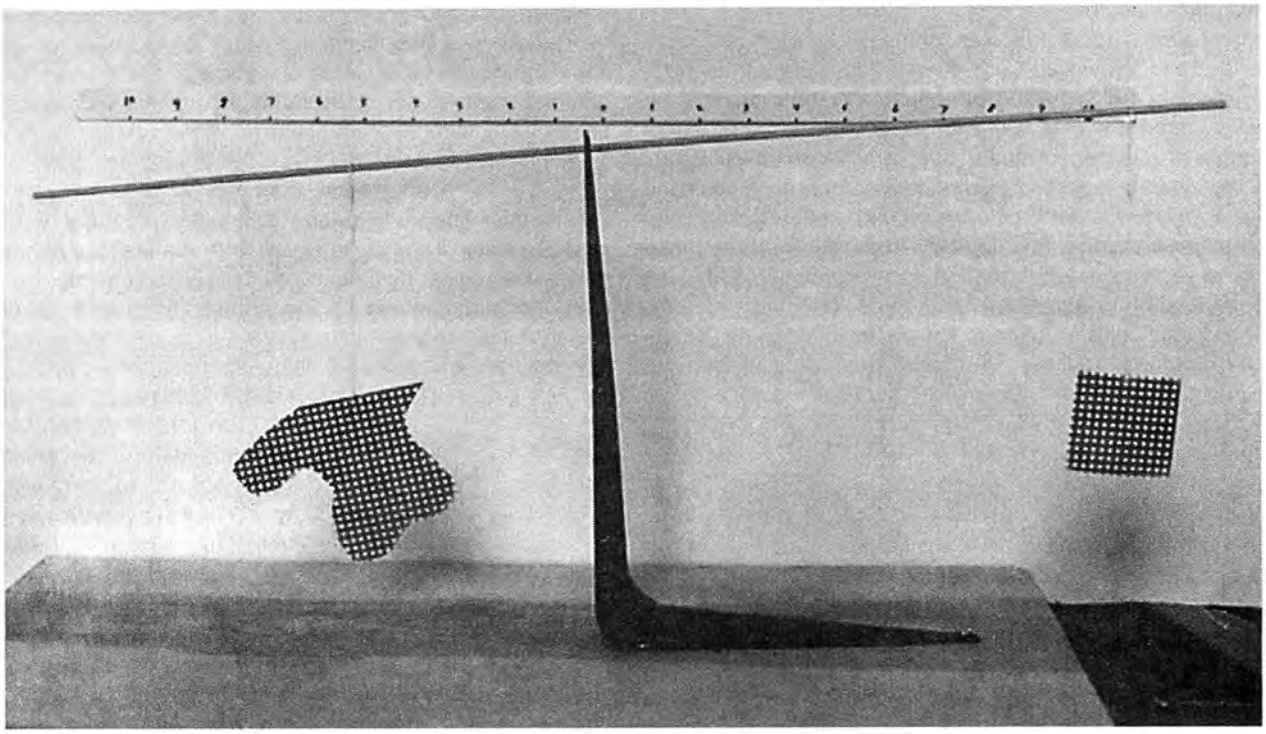


Figure 6
MEASURING AN IRREGULAR AREA
An irregular area, such as that on the left, can be measured by balancing it with a unit square.

Archimedes to show, for example, that numbers like the square root of 2 are irrational (that is, cannot be expressed as ratios of integers), and to determine the volume and surface area of various solids such as cones. (In his letter to Eratosthenes, Archimedes makes reference to Eudoxus' work in this area.)

Thus, the ordered series formed by the technique of exhaustion are asymptotic, converging on a limit if extended to infinity. On the other hand, the ordered series of the center of gravity method are, as one might expect from the employment of a balance, a series of perfect equalities involving no asymptote or convergence but only coherence between the parts and the whole, and a one-to-one, unique correspondence between the parts themselves. (In fact, these series are perfect elementary examples of the Cantorian definition of equivalent sets.[5])

Archimedes' employment of the center of gravity method has caused fits among 20th century logical positivists like Ernst Mach. Such logicians—evidently because of their fear of non-Euclidean solutions of geometric propositions, or fear of Georg Cantor, or both—hysterically fail to see the difference between a tautological proposition and one based on a self-reflexive coherence.

Squaring the Circle

Archimedes packed quite a one-two punch by combining the center of gravity method of scientific investigation with the technique of exhaustion, or exhaustive logical proof. This is, as we shall see, most clearly and profoundly borne out in Archimedes' quadrature of the parabola and his comparison of the surface areas and volumes of the sphere, cone, and cylinder in terms of simple ratios of a unit circle, or what we call π. However, as previously stated, there was no number called π when Archimedes lived, and, moreover, Archimedes knew that he did not know what such a number might be. Neither the technique of exhaustion nor the center of gravity method was of any avail in determining what sort of number π might be.

Nicholas of Cusa, the great philosophical genius of the Renaissance, was, in about 1440, the first to recognize and rigorously prove that, in fact, an entirely new type of number (later called transcendental) was needed to define what we call π; that π could not be considered whole, fractional, or irrational (like the square root of 2). By standing on Archimedes' shoulders, Cusa was able to see something Archimedes never himself saw: the necessity to create higher orderings of numbers than the Greeks had known.

Series were eventually found to approximate the circumference of the circle in terms of its diameter, but none was ever found to converge, as did Archimedes' quadrature of the parabola, on a known number, whether whole, fractional, or irrational. Some series were based on successive approximations with inscribed and circumscribed polygons, whose numbers of sides are continuously doubled (as Archimedes had attempted). Some were based on a technique developed by Nicholas of Cusa himself: that some geometric figure approximately equivalent to the circle's circumference in length and susceptible to analysis in terms of an exhaustive series, be used for such an approximation. In 1674, the great discoverer of the calculus, Gottfried Leibniz, formed such a series for 1/4 π,

namely $1 - 1/3 + 1/5 - 1/7 + \ldots$. But all of these series are only approximations.

Many similar series followed, some by Newton and some later by Euler. However, Cusa, Kepler, Huygens, and Leibniz, who pioneered this method of approximate quadrature, were always circumspect, as was Archimedes before them, about claiming a true, perfect quadrature of any curvilinear figure, whether an infinite series could be formed or not. Newton and Euler, logicians first and scientists second, both attacked Leibniz for not accepting the "logical" implication—the equivalence of rectilinear and bounded curved figures—of his own proofs based on infinite series.

The inability of the Greeks to square the circle using Pythagorean methods, and the even more frustrating inability to prove that π was an irrational number—like the square root of 2 (which also depends logically on a proof involving exhaustive series)—was their stumbling block: How could one hope to determine the surface area or volume of a sphere, for example, or a conic section, if even the circumference of a circle is not provably rational or irrational?

Some Examples

With this in mind, let us conclude our exploration of Archimedes' center of gravity method as it applies to a field normally reserved for Euclidean geometry, supplemented by Eudoxus' technique of exhaustion; namely, the determination of the area and volume of some curvilinear geometric figures. The first three examples are elementary heurisms, not actually contained in Archimedes' "Method." I have included them to establish the principle involved in an elementary way. The last two examples are from Archimedes' "Method."

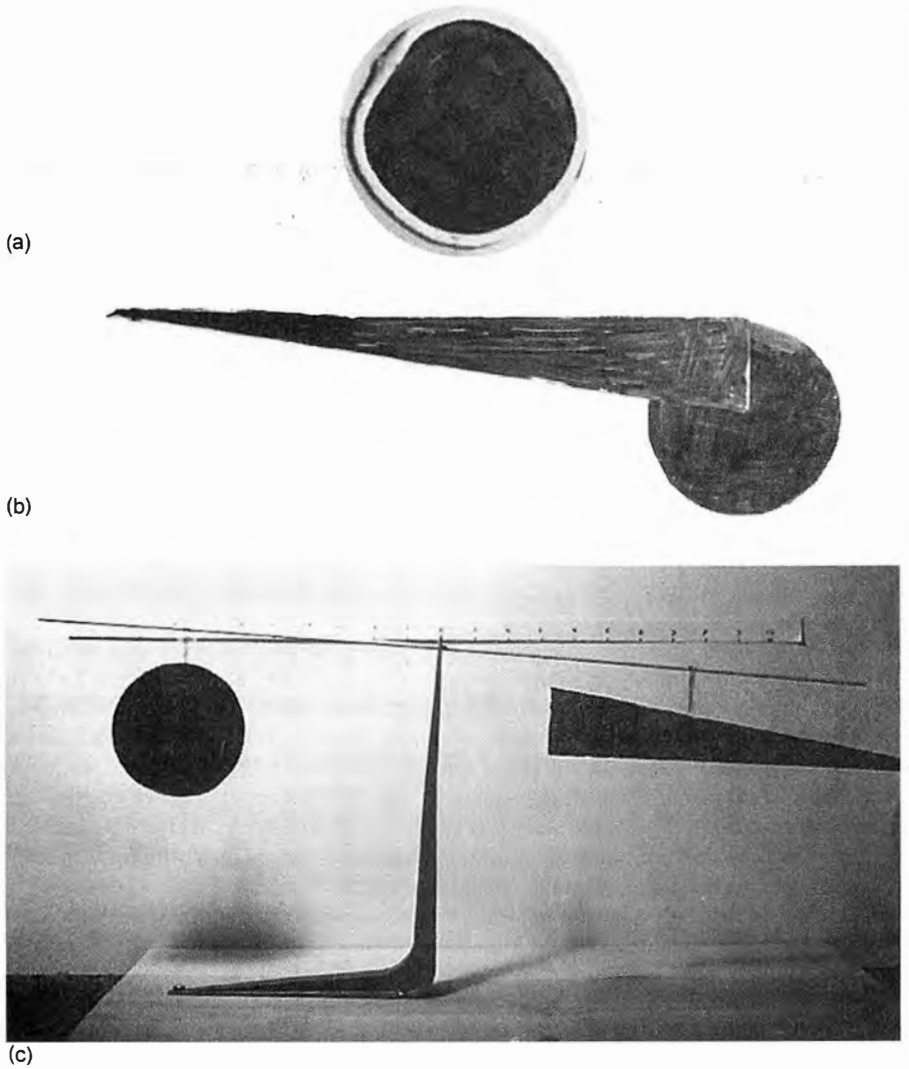


Figure 7
A RIGHT TRIANGLE OF AREA EQUAL TO THAT OF A GIVEN CIRCLE
Wrap a rope around a circle and then construct a right triangle making the longest side the length of the rope (the circumference of the circle) and the short side the length of the circle's radius. The triangle and the circle will balance at equal distances from the fulcrum.

(1) Figure 6 shows an irregular area measured by a unit square on a balance. This is a simple solution to one of the problems mentioned before: how to measure an area that is very difficult to triangulate. No ordered series is created, either center of gravity or exhaustive.

(2) The area of the circle, as we all know from school, is πr^2. But how do we know this, and why is it so? To answer the first question, the center of gravity method comes in very handy. We can see in Figure 7 that a right triangle with one leg equal to the radius of a circle and the other equal to the circumference of that same circle, will have an area of $1/2\ r \times 2\pi r$, which equals πr^2. Will a triangle so constructed balance, at an equal distance, the circle from which it was derived?

As to why the two figures balance, stated strictly in terms of Euclidean axioms, this is best explained by the technique of exhaustion. Archimedes shows (Figure 8) that by successively doubling the sides of inscribed and circumscribed polygons about the circle, as was attempted in measuring the circumference, the common height of the isosceles triangles that are defined by the center of the circle and the sides of the polygons will converge on the

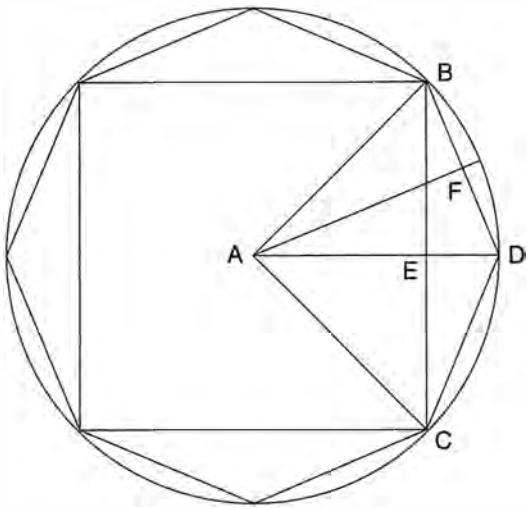


Figure 8
FINDING THE AREA OF A CIRCLE USING THE TECHNIQUE OF EXHAUSTION

As the number of sides of a polygon inscribed in the circle is successively doubled, the height of the triangles, such as AE in triangle ABC and AF in triangle ABD, approaches length AD, the radius of the circle. The sum of the lengths of the bases of the triangles composing the polygons, such as BC in the square, or BD and DC in the octagon, approach the length of the circumference of the circle. The total area of the successive polygons, equal to the total area of the triangles composing them, thus approaches 1/2 × radius × circumference, and circumference = πr^2.

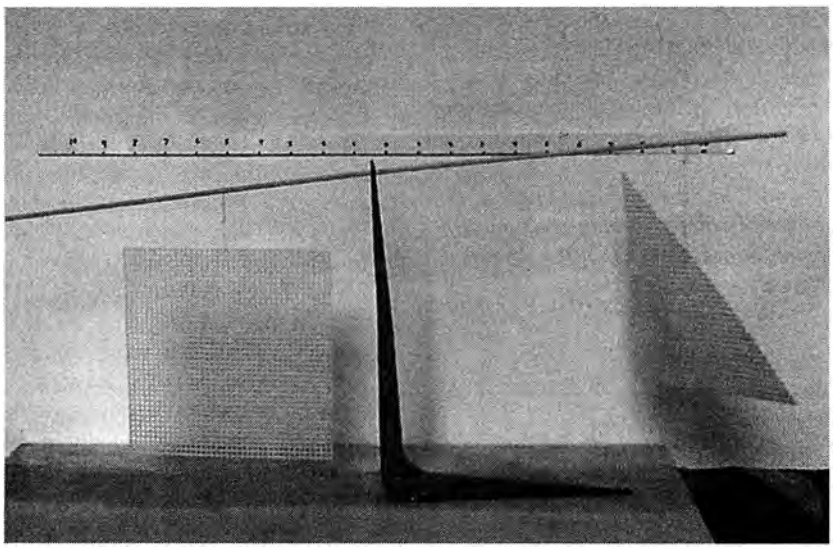


Figure 9
THE BASIC LAW OF THE BALANCE

A whole square balances a half-square at 1/2 its distance from the fulcrum, according to the basic law of the balance: mass × distance on one side of the fulcrum must equal mass × distance on the other side. The squares here are constructed from a mesh material.

radius, and the sum of their bases will converge on the circumference.

Therefore, even if the circumference does not exist from the logic of the polygons per se, if we take π as a real existence, we can then determine that the area of the circle could not be less than, or greater than, precisely πr^2.

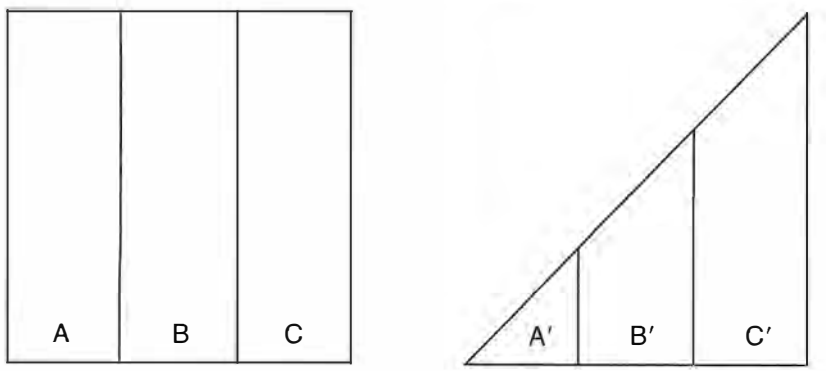
(3) Consider a simple square, Figure 9. Its axes of gravity must all go through its center of gravity, which can be defined as the intersection of the two diagonals. (We assume that the thickness of the surface and its specific gravity are uniform.)

Divide the square in half along one of its diagonals. As you might expect, the half-square must be placed twice as far from the fulcrum as the whole square to achieve a balance. But if we did not know that dividing a square along its diagonal exactly halves it, how might we check to see whether this method produces a true half-square and not merely a good approximation?

Create an ordered series, by dividing the whole square and the supposed half square into equal numbers of vertical strips of corresponding widths (Figure 10). Design the experiment—the experimental design is always crucial—so that the strips of the supposed half square, when hung successively from a fixed point (arbitrarily chosen) on one balance arm, just balance the corresponding strips of the whole square.

Here's what is key. The intervals between suspension points for the strips of the whole square will be equal. Find the midpoint between the points of suspension for the first and last strips. *If the half-square is a true half, the distance from the fulcrum to this midpoint will be half of the distance from the fulcrum to the fixed point from which the segments of the half-square were hung.* It doesn't matter how many strips were created from the square and half-square. It doesn't matter how widely the strips of the square have to be spaced, based upon the choice of the fixed point on the other arm of the balance.

This example, unlike the first two, is not a simple empirical measurement but involves a test of coherence



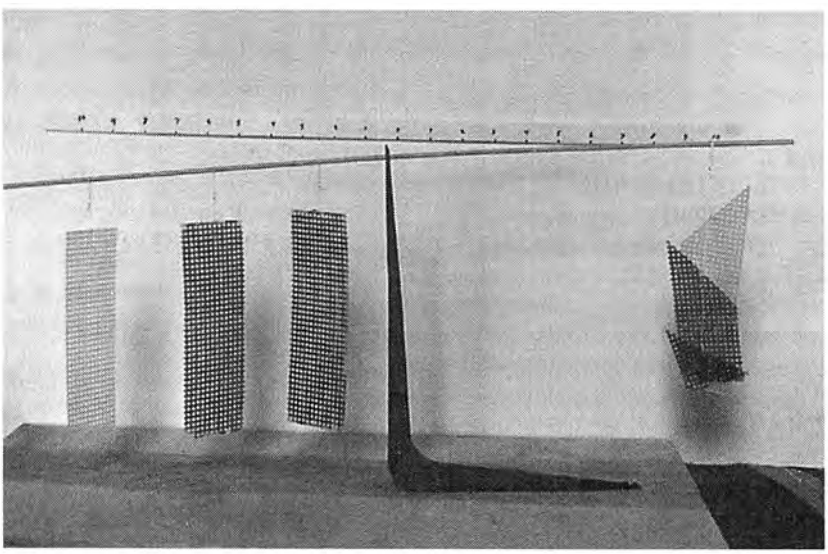


Figure 10
DOES A DIAGONAL BISECT THE SQUARE?

To determine whether a square divided along a diagonal (as in Figure 9) cuts it exactly in half and is not just an approximation, cut the square and the supposed half-square into equal numbers of vertical strips of corresponding widths. Find points at which corresponding strips A and A′ balance. Replace A′ with B′—hanging it at the same point—and find the point at which B balances B′. Replace B′ with C′ and find the point where C balances C′, and so on. If intervals AB, BC, and so on, are equal, and if the midpoint between the first and last of these suspension points is half as far from the fulcrum as the fixed point of suspension on the other arm, then the supposed half-square is truly half the area of the square.

of the initial measurement with the creation of an ordered sequence. This is what gives us sufficient reason to believe—if we did not already know—that the divided square is one half the whole square.

With this principle, Archimedes makes visible the invisible: The area of a figure is measured by means of linear distances along the balance arms. Archimedes does not actually present this simple example, but understanding the principle involved will clarify the more difficult examples from his writings that follow.

(4) Figure 11 shows Archimedes' demonstration, using the center of gravity method and then the technique of exhaustion, to show that the area of any parabolic section is exactly 4/3 the area of the maximum triangle inscribable within it.

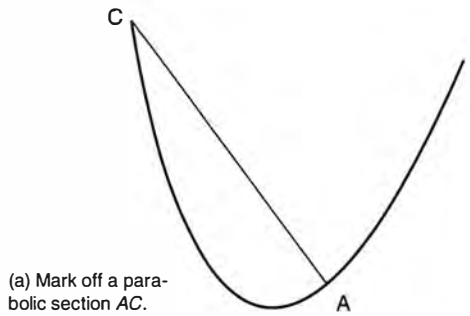
Mark off the segment that is to be measured, for example, *AC* in Figure 11, and then unwind a string from the parabola allowing it to remain tangent at *C* (this is the involute of the parabola). Mark off a section of the involute, *CF,* such that *FA* is parallel to the axis of the parabola *XY*. Fold *FCA* to form a median *CK*. Find the midpoints of *CF* and *AC* and by connecting them, form line *DBE*. Note that the triangle *ABC* is the maximum triangle that may be inscribed within the parabolic section *AC*.

It is apparent, by construction, that triangle *AFC* has twice the area of triangle *AEC*. But triangle *AEC* has twice the area of triangle *ABC;* therefore, triangle *AFC* has four times the area of triangle *ABC*.

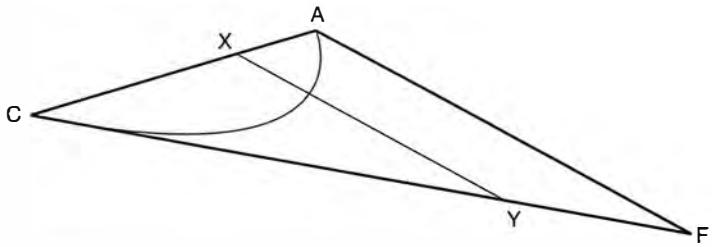
Now, the areas that Archimedes wants to balance against each other are triangle *AFC* and the parabolic section bounded by the line *AC*. A balance is constructed—*CKH* with its fulcrum at *K*. The entire parabolic section *AC,* placed at one end of the balance *H,* balances the entire triangle *AFC,* placed 1/3 of the distance to the other end of the balance *C*. This gives a rough idea that the parabolic section *AC* is 1/3 the area of the triangle *AFC*.

Next, in a manner precisely similar to the way we cut the whole square and the square divided by the diagonal into strips (Figure 9) with a one-to-one correspondence to each other, Archimedes cuts the parabola *AC* and the triangle *AFC* into a series of strips in one-to-one correspondence; for example, *MO* and *PO, ED* and *BD,* and *QU* and *RU*. (In this case, Figure 11(e), wooden dowels were used to represent the strips but, of course, strips work also.)

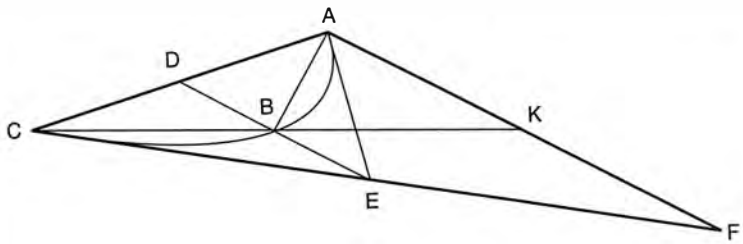
As in the previous example, the strips of the parabolic section *AC,* such as *PO, BD,* and *RU,* when placed at the arbitrary position *H* at one end of the balance, exactly balance the strips of the triangle *AFC,* such as *MO, ED,* and *QU,* when placed at a succession of points along the balance corresponding precisely to their original locations along the median *CK*. However, the ratio of the balance arms, when the parabolic section and triangle *AFC* balance, is not 2 to 1 as with the half-square and square. Instead it is 3 to 1. Thus, Archimedes has created an ordered series, providing sufficient reason to believe that the original "ballpark" measurement, which showed the parabolic section *AC* to be 1/3 of the triangle *AFC,* is true. The parts cohere with the whole.



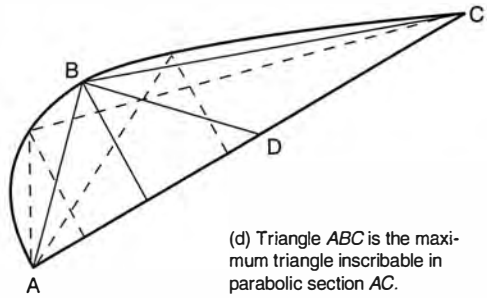
(a) Mark off a parabolic section *AC*.



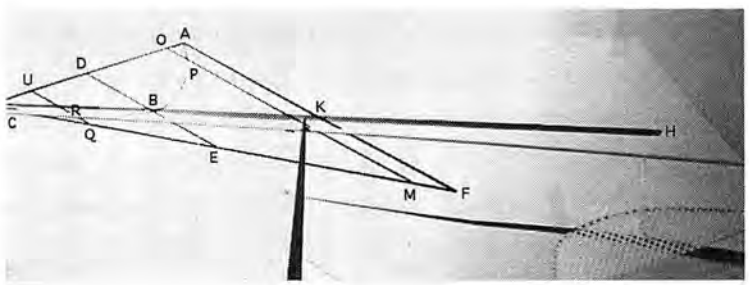
(b) *FA* is parallel to the axis *XY*. *CF* is tangent to the parabola at *C*.



(c) *CK* is a median of triangle *FCA*. *DBE* joins midpoints of *CF*, *CK*, and *CA* and is parallel to *FKA*.



(d) Triangle *ABC* is the maximum triangle inscribable in parabolic section *AC*.



(e) Section *MO* balances section *PO* at *H*. Sections *MO* and *ED* balance sections *PO* and *BD* at *H*. Sections *MO*, *ED*, and *QU* balance sections *PO*, *BD*, and *RU* at *H*.

Figure 11
QUADRATURE OF THE PARABOLA USING THE CENTER OF GRAVITY METHOD

Archimedes demonstrated that the area of any section of a parabola is exactly 4/3 the area of the maximum triangle inscribable within it.

As shown in (a), mark off the parabolic section to be measured, AC. Unwrap a string from the parabola, forming a straight line tangent at C (the involute of the parabola). Mark off a section of the involute CF so that FA is parallel to the axis of the parabola XY (b). (Look back to 11(a) if axis XY appears drawn incorrectly here!) Fold FCA to form a median CK (c). Find the midpoints of CF and AC and connect them to form the line DBE. Triangle ABC is the triangle of maximum area inscribable in parabolic section AC (d).

It can be shown by construction that the triangle AFC has twice the area of AEC, which has twice the area of ABC. Thus the triangle AFC has four times the area of triangle ABC.

Balance the parabolic section AC on one arm with triangle AFC, placed one-third of the distance on the other arm of the balance. This shows roughly that AC is one-third the area of AFC.

Finally, using a method similar to that in Figure 10, cut the parabola and the triangle into a series of strips and balance the corresponding sections of each, one pair at a time. This is shown in (e). Wooden dowels (not shown) were used to represent the strips. The geometric construction is superimposed near the balance arm to show that intersections with the median CK indicate where the dowels must be suspended.

Because the triangle *ABC* is 1/4 the area of the triangle *AFC*, the parabolic section *AC* is shown to be 4/3 of the maximum triangle *ABC* inscribable within it.

The same result is achieved, but in a way intended to convince even a Euclidean formalist, with the technique of exhaustion. Triangles are successively inscribed, as shown in Figure 4, converging asymptotically on an area that is 4/3 of the triangle initially inscribed, when summed together. This is so because the combined areas of each succeeding set of triangles is, in a self-similar progression, exactly 1/4 the area of the previous set: 1 + 1/4 + 1/16 + . . ., which, if extended infinitely, is provably neither more than nor less than 4/3 (is not

other than 4/3).

Note that we have measured the area of a parabolic section, not the entire parabola, because the parabola and the hyperbola are both infinite conic sections. Thus, what Archimedes actually measured was an "infinitely" small microcosm of the entire parabola, even though the figure is in every case quite definite.

(5) Archimedes proves, using the center of gravity method and then the technique of exhaustion, that the volume of a sphere is 2/3 that of a cylinder that has a diameter and height equal to that of the sphere. This center of gravity experiment is the one Archimedes had placed on his tombstone.

In this case (Figure 12), Archimedes is balancing three objects: a sphere, a cone, and a cylinder. The cone and cylinder each have heights equal to the diameter of the sphere, but the diameters of their bases are twice that of the sphere.

The sphere will balance the cylinder when the sphere is placed 6 times farther from the fulcrum than is the cylinder. One might therefore suspect that the sphere is 1/6 the volume of the given cylinder, or 2/3 the volume of a cylinder whose height and base are both equal to the diameter of the sphere.

The cylinder will balance the cone at 1/3 the distance of the cone, but Archimedes already knew that the cone is 1/3 the volume of the cylinder that has the same base and height.

The cone and sphere together will balance the cylinder at 1/2 their distance from the fulcrum. This makes sense, because the sphere, at 1/6 the volume of the cylinder, and the cone, at 1/3 the volume of the cylinder, will together equal 1/2 the volume of the cylinder.

What is remarkable in this case is that an ordered unique series of balanced parts (in this case, comparing cross sections of the three bodies) is possible only with all three bodies and not with any two of them, as shown in Figure 12(e). The cone and the sphere (or corresponding sections thereof) are suspended together at one fixed point on the balance, against the cylinder (or corresponding sections of the cylinder) placed in an ordered series.

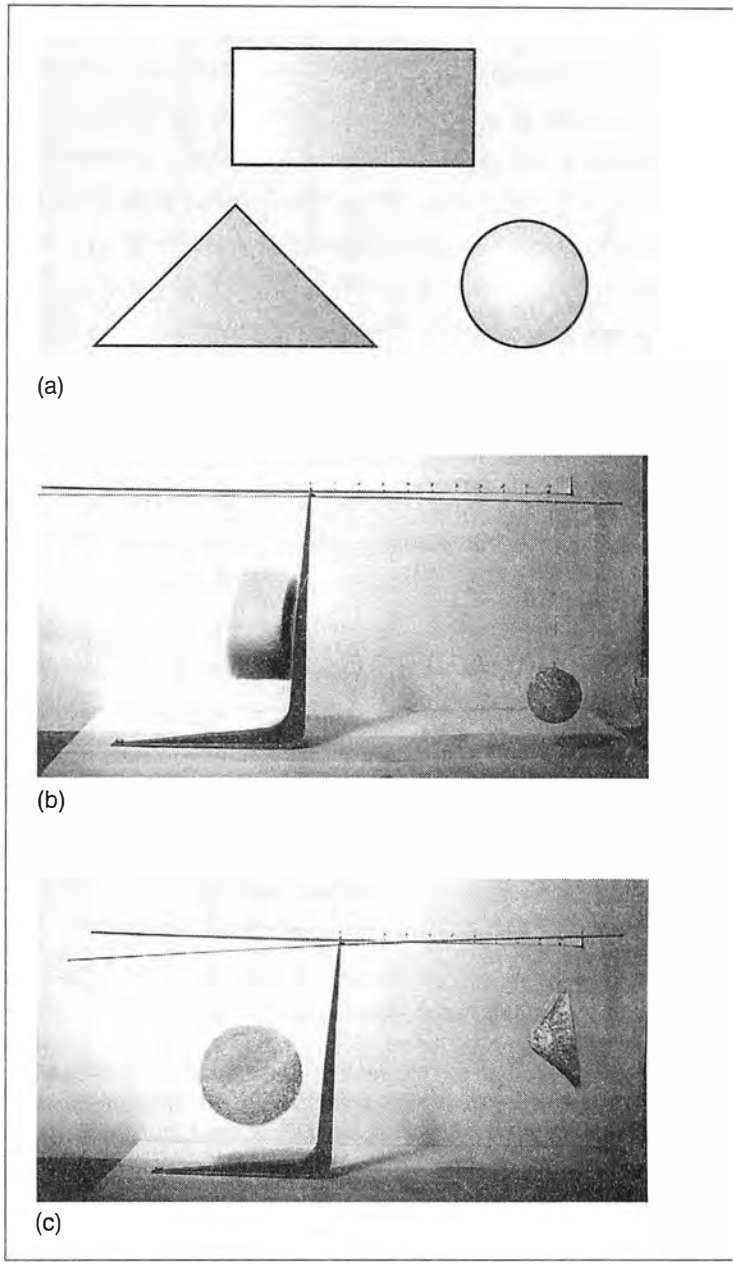
Archimedes created an ordered series of cross sections, suspending the corresponding sphere and cone cross sections together at a fixed point G, at one end of the balance arm, against the corresponding cross sections of the cylinder at the succession of positions along the axis/balance arm FE from which the sections of cone, sphere, and cylinder were sliced, $SRQP$ in Figure 12(e).

Now the cylinder has one thing in common with the square of Example 3: Its center of gravity is at the midpoint of its axis of rotation. Therefore, if the ordered series of cross sections balances in a one-to-one fashion, as it does in the photographs, it confirms, rather beautifully, that the cylinder is indeed twice the volume of the sphere and cone combined.

However, if the volume of a sphere is thus shown to be 1/6 that of a cylinder with a height equal to the sphere's diameter but with a base that is twice the diameter of the sphere, then its volume will be 2/3 of a cylinder with height and base both equal to its diameter, because this cylinder will have 1/4 the volume of the former one.

This, in turn, translates simply into what has come down to us as Archimedes' discovery: The volume of a sphere is equal to $4/3\ \pi r^3$.

We omit here Archimedes' proof of this same proposition by the technique of exhaustion, although I recommend that readers review it independently. In addition, Archimedes determined through exhaustion that the surface area of a sphere is neither greater than, nor less than, 4 times the surface area of a great circle of the sphere.

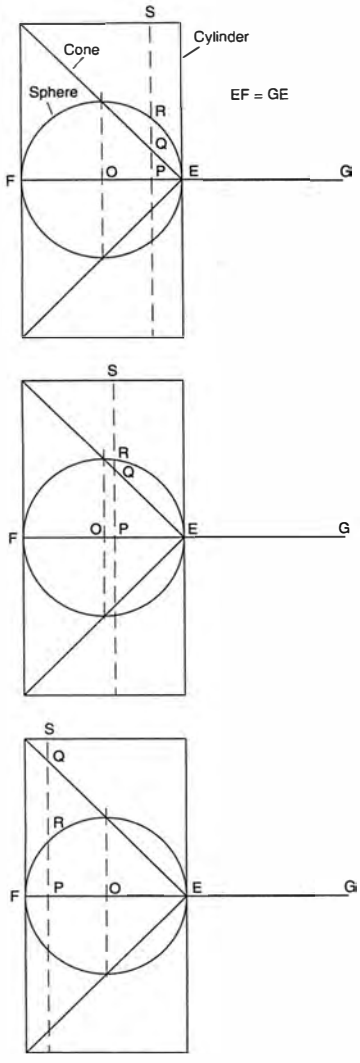

(a)

(b)

(c)

From these examples, we see more clearly the paradox with which Archimedes was confronted. The technique of exhaustion was inadequate to define the circumference of the circle in terms of its diameter—inadequate to define what we call π. The paradox was that such measurement of the circle, though undefined by any self-similar exhaustive series, could itself be used to determine perfectly self-similar series for the area of a circle (πr^2), the volume of a sphere ($4/3\ \pi r^3$), and the surface area of a sphere (4 times the area of its great circle). Not only that, but one conic section, the parabolic section, Archimedes defined with no reference to π whatsoever, as 4/3 the maxi-

(d)



(e)

Figure 12
BALANCING A SPHERE, CONE, AND CYLINDER TO MEASURE THEIR VOLUMES

A cone, cylinder, and sphere each have the same height, but the cone and cylinder each have a base twice the diameter of the sphere (a).

As shown in (b), the sphere balances the cylinder when the sphere is placed 6 times farther from the fulcrum than is the cylinder. The cylinder balances the cone at 1/3 the distance of the cone (c). The cone and sphere together balance the cylinder when it is 1/2 their distance from the fulcrum (d).

Archimedes created an ordered series of cross sections (e), as done in Figures 10 and 11, and balanced them to confirm that the cylinder is twice the volume of the sphere and cone combined. In this manner, Archimedes also determined that the volume of a sphere is equal to 4/3 πr^3.

Archimedes' tombstone, at his direction, was engraved with a diagram similar to (e).

(e) A schematic of Archimedes' method. FEG represents both the balance with fulcrum at E, and the axis of rotation for sphere, cone, and cylinder. A plane PS (dashed line), perpendicular to GF at any point P will cut the sphere, cone, and cylinder in circles with radii PR, PQ, and PS, respectively. (The cylinder, with axis EF, is seen edge-on.) Three successive, arbitrary cuts designated PS are shown. Archimedes proved that the circles cut in any plane PS from the sphere and cone (their weights proportional to their areas) placed on the balance FEG at G would exactly balance the circle cut from the cylinder placed at P. From this he derived the volume of a spherical segment, as well as the volume of a whole sphere ($4\pi r^3/3$).

mum triangle inscribable within it!

Archimedes' discovery of the concept of center of gravity, and his brilliant use of the balance to construct crucial experiments, enabled him to see in such paradoxical results not a stumbling block, but the necessity for science always to find new forms of measurement coherent with its own advance.

Bob Robinson, a graduate of Johns Hopkins University, works with the Schiller Institute in Norfolk, Virginia, and enjoys delving into the history of science.

Notes

1. The author's article about Greek astronomers Aristarchus and Eratosthenes, "Measuring the Unseen," will appear in a future issue of *21st Century*.
2. Thomas L. Heath, 1953, *The Works of Archimedes* (New York: Dover Publications), pp. 221-222.
3. Plutarch, n.d., "Marcellus," in *Plutarch's Lives*, translated by John Dryden (New York: Modern Library), pp. 377-379.
4. Heath, *The Works of Archimedes*, p. 13.
5. Georg Cantor, 1955, *Contributions to the Founding of the Theory of Transfinite Numbers* (New York: Dover Publications), p. 86, last paragraph, and pp. 60-61 of the Introduction.

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E.J. Dijksterhuis, 1987. *Archimedes* (Princeton: Princeton University Press).

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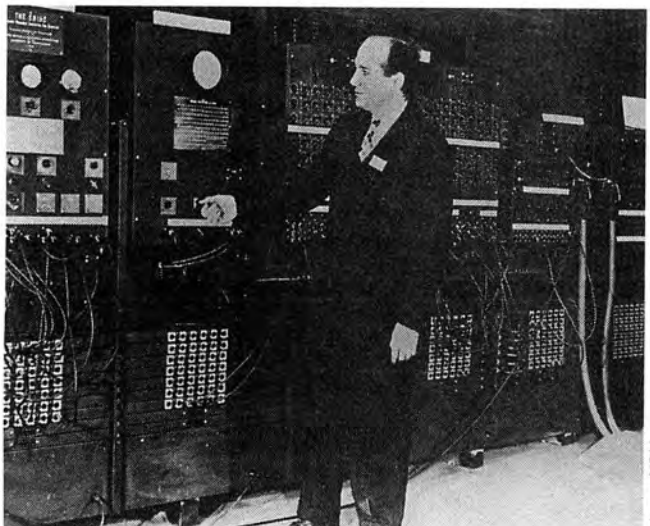
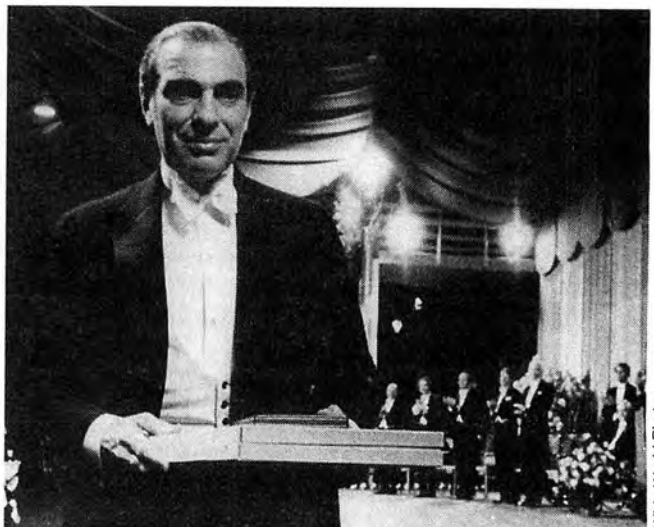
William W. Strader and Lawrence D. Rhoads, 1934. *Planar Geometry* (Philadelphia: John C. Winston Co.).

A.M. Welchans and W.R. Krickenberger, 1955. *Solid Geometry* (Boston: Ginn and Co.).



Courtesy of IBM

1946



AP/Wide World Photos

1972

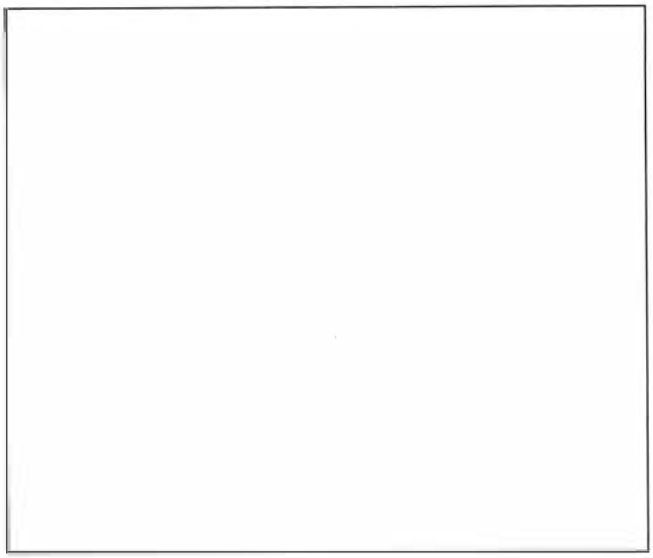
Kenneth Arrow Runs Out of Ideas, But Not Words

An exposé of Science *magazine's promotion of environmentalist mumbo-jumbo as peer-reviewed objective science.*

by Lyndon H. LaRouche, Jr.

As I read the item in the April 28 issue of *Science* magazine,[1] I was saddened by the fact that co-author Arrow had fallen so low as to associate himself with such a pathetic piece.

I had first encountered Kenneth Arrow's work four decades ago, in the course of my post-1948, continuing warfare against the intrinsic incompetence of the "information theory," economic "systems analysis," and "brain theories" of Norbert Wiener[2] and John von Neumann.[3] That first encounter was Arrow's contribution to a book published in 1951.[4] The "modelling" techniques developed by the the war-time "operations researchers" in Britain and the United



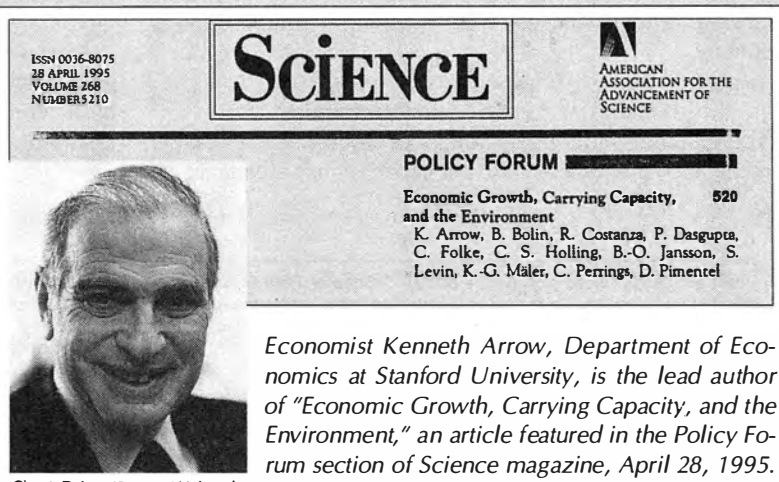
1995

Opposite page, far left: The ENEAC, an early computer, built at the University of Pennsylvania. Center: Kenneth Arrow carries his Nobel Prize for economic science in Stockholm.

States, such as Arrow, had worthwhile engineering applications in military logistics and related economic matters; but, to premise a theory of political-economy upon such techniques, was charlatanry.

Then, four decades ago, my interest in the "operations research" (OR) literature, was to define, as precisely as possible, the point at which OR's often useful engineering techniques crossed the line, from reality, into quackery. A bit later, still during the 1950s, I found myself briefly in alliance with Harvard's Professor Wassily Leontief, against what Leontief then described fairly as the "ivory tower" fanatics within the salons of Tjalling Koopmans's Operations Research Society. Arrow has joined those fanatics.

Respecting either economics, or the theory of the human brain, the crucial point to be made, four decades ago, and still today, is that there was nothing original axiomatically in the propositions advanced by Professor Norbert Wiener's "information theory," John von Neumann's "systems analysis," or Tjalling Koopmans' "ivory tower" faction in "operations research." At that time, I argued that these positivists, Wiener and von Neumann, had resurrected the same fallacious argument central to the *Critiques* of Immanuel Kant, but with less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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

POLICY FORUM

Economic Growth, Carrying Capacity, and the Environment 520
K. Arrow, B. Bolin, R. Costanza, P. Dasgupta, C. Folke, C. S. Holling, B.-O. Jansson, S. Levin, K.-G. Mäler, C. Perrings, D. Pimentel

Chuck Painter/Stanford University

Economist Kenneth Arrow, Department of Economics at Stanford University, is the lead author of "Economic Growth, Carrying Capacity, and the Environment," an article featured in the Policy Forum section of Science magazine, April 28, 1995. Among Arrow's coauthors is Cornell University's David Pimentel, who has openly called for reducing the world population to 2 billion, in the name of "carrying capacity."

1. Kenneth Arrow, Bert Bolin, Robert Costanza, Partha Dasgupta, Carl Folke, C.S. Holling, Bengt-Owe Jansson, Simon Levin, Karl-Göran Mäler, Charles Perrings, David Pimentel, 1995. "Economic Growth, Carrying Capacity, and the Environment," *Science*, April 28, pp. 520-521.
2. Norbert Wiener, 1948. *Cybernetics, or Control and Communication in the Animal and the Machine* (New York: John Wiley & Sons).
3. John von Neumann and Oskar Morgenstern, 1953. *The Theory of Games & Economic Behavior*, 3rd ed. (Princeton, N.J.: Princeton University Press).
4. Kenneth Arrow, 1951. "Alternative Proof of the Substitution Theorem for Leontief Models in the Case of Three Industries," in *Activity Analysis of Production and Allocation*, Tjalling Koopmans, ed. (New York: John Wiley & Sons).

elegance than Kant had done.[5] That was, and is still a valid observation. Today, I would prefer to emphasize, that the *axiomatically* essential features of "information theory" and "systems analysis" were stated plainly more than two centuries ago, by the influential Venetian monk Giammaria Ortes.[6]

Today, Arrow and his co-authors are still plagiarizing the arguments of 18th century Venetian monks.[7] The contribution of Arrow et al. to *Science* magazine's April 28 "Policy Forum," contains nothing more in idea-content than a new plagiarism of the same Giammaria Ortes's 1790 *Popolazione delle nazioni per supporto all'economica nazionale* [8] whose English edition[9] was plundered by Thomas Malthus's famous *An Essay on the Principle of Population* in 1798.[10]

The notion of "carrying capacity," as employed in this *Science* piece of Arrow et al., is specifically original to Ortes. It was an aspect of Ortes's 1790 *Popolazione* . . . which was left behind by Malthus in the process of bowdlerizing Ortes's original work. This feature of Ortes's original version of what is known as the Malthusian dogma, was revived from the archive during the course of the early 1980s.

This resurrection of Ortes's "carrying capacity" came in response to the mounting ridicule of the plainly fraudulent, early version of the Club of Rome's argument, in the Meadows-Forrester *Limits to Growth*.[11] Attacks upon the Club of Rome's initial argument[12] had not halted the massively funded spread of the neo-Malthusian ideology, but had spoiled its acceptance in governmental circles. In this circumstance, the Club of Rome resurrected Ortes's notion of "carrying capacity."[13]

That much introduction has now prepared us to address directly the content—and also want of content—within the piece before us.

'Carrying Capacity' and Economics

Today, many millions of dollars of Rockefeller and other funding later, the phrase "carrying capacity" has seemingly acquired the powers of post-hypnotic suggestion among its true believers. In such milieus, today, it enjoys the authority of an axiom: among its devotees, whatever is uttered under the aura of this magic phrase, is instantly defended, often with great passion. Such is the rhetorical style, and content, of the argument set before us by Arrow et al.

Arrow et al. come to the point of their piece with the following statement:

> In this article we discuss the relation between economic growth and environmental activity, and the link between economic activity and the carrying capacity and resilience of the environment.

A footnote to that statement provides the following relevant information on background:

> This [article] is a report of the Second Askoe Meeting, held 31 August to 2 September 1994 . . . outside Stockholm, Sweden. The meeting was organized by the Beijer International Institute of Ecological Economics, Royal Swedish Academy of Science. . . . The aim of the meeting was to establish a substantive dialogue among a small group of ecologists and economists to gauge whether an interdisciplinary consensus exists on the issues of economic growth, carrying capacity, and the environment and to determine what could be said about the joint development of economic and environmental policy.

After reading that explanatory footnote, one should not expect scientific rigor from what the authors have admitted to be a "consensus" uttered jointly by representatives of such assorted, axiomatically immiscible contemporary advocacies.

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5. See Kant on "synthetic judgment a priori," *Critique of Pure Reason*, passim. My own mid- to late-adolescence studies in the epistemology of scientific method, had been forged in a defense of Gottfried Leibniz against Kant's attacks on this matter of ideas. Thus, my initial, late 1940s, approach to the abhorrent features of "information theory" and "systems analysis," had been to treat them as philosophically radical expressions of neo-Kantian positivism.
6. Giammaria Ortes (1713-1790), *Della economia nazionale libri sei* (1777). Ortes, together with the hoaxster Pierre-Louis Maupertuis, is credited with being among the first to apply what was termed the "hedonistic calculus" (for example,"Newtonian social science") to both economics doctrine and the theory of "human nature."

   This is the 18th century origin of Norbert Wiener's efforts to reduce the content of "ideas" to a quality of "information-content" assumedly subject to statistical interpretation. The "hedonistic calculus" of Ortes is also the origin of the axiomatic assumptions of John von Neuman's "systems analysis." Ortes was nominally a Camaldolesian monk, of that sort whose vows were more or less continuously in abeyance. He was among the leading Venice intelligence operatives in Venice spy-master Antonio Conti's 18th century network of salons.
7. Most notable, is Abbot Antonio Conti (1677-1749), Venice's leading spy-master during the first half of the 18th century. Typical of Conti's network is Abbot Guido Grandi of Pisa, the educator of both Ortes and of the Venice spy, Francesco Algarotti (the author of the book *Newton for Ladies*), whom Conti's salon planted upon Prussia's Frederick II ("the Great"). It is a notable indication of the condition of today's university curriculum in history, that the names of Conti and Ortes, two of the most influential figures of 18th century European history in general, and the history of science in particular, do not appear in such indicative locations as the *Encyclopaedia Britannica*.

   Conti's salon created Montesquieu and Voltaire, coordinated the Europe-wide attacks on Leibniz's influence on science, directed Casanova's operations in France, created the Physiocrats, controlled much of the policy of Frederick II's Prussia (including the Berlin Academy of Science) from the inside, and created the modern radical empiricism of Adam Smith, Jeremy Bentham, et al., in addition to fabricating and spreading the dogma known today as "Malthusianism."

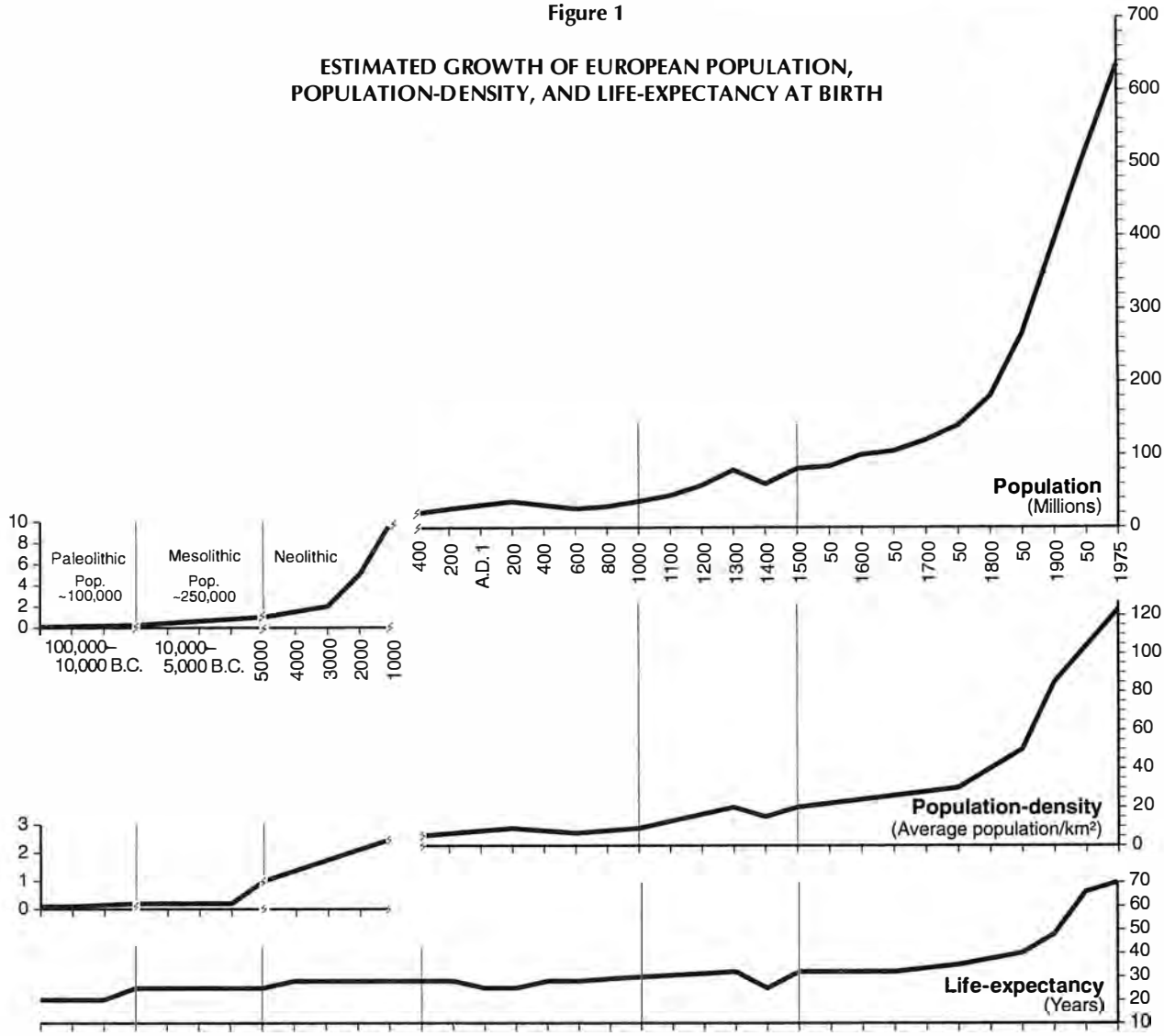
   On the present-day influence of Conti's salon, see Lyndon H. LaRouche, Jr., "How Bertrand Russell Became an Evil Man," *Fidelio*, Fall 1994, passim.
8. Published in Venice in 1790. Since the revival of his dogma of "carrying capacity," Ortes himself has also enjoyed a literary resurrection: see Piero del Negro, *Giammaria Ortes: un "filosofo" veneziano del Settecento* (Florence, Italy: L.S. Olschki, 1993). For a library source on Ortes's writings as an economist, see *Scrittori classici italiani di economia politica*, P. Custodi, ed. (Milan: G. G. Stefanis, 1803-1816).
9. *Reflections on the Population of Nations in Respect to National Economy.*
10. Thomas Malthus, [1798]. *An Essay on Population* (New York: E.P. Dutton and Co., 1960).
11. Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens, III, 1972. *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (Washington, D.C.: Potomac Associates, New American Library).
12. Typical of the argument against Meadows and Forrester is my own *Es Gibt Keine Grenzen des Wachstums* (Wiesbaden, Germany: (Club of Life) Campaigner Publications Deutschland, 1983). This was later published in English as *There Are No Limits to Growth* (New York: New Benjamin Franklin House, 1983), and enjoyed an influential, if modest circulation in Europe, the Americas, and elsewhere.
13. See Webster G. Tarpley, 1994. "Giammaria Ortes and the Venetian Hoax of Carrying Capacity," *The New Federalist*, June 20, pp. 6-9.

Like many pro-environmental consensual utterances written in a similar spirit: like a practical joker's staging of an empty suit of clothes sitting in a chair, it pretends to contain precisely that quality of scientific deliberation which is entirely lacking within. That we might not be presumed to be exaggerating the contemptibility of that item from *Science,* we quote the article's concluding paragraph in its entirety.

> Economic growth is not a panacea for environmental quality; indeed, it is not even the main issue. What mat-

Figure 1

ESTIMATED GROWTH OF EUROPEAN POPULATION, POPULATION-DENSITY, AND LIFE-EXPECTANCY AT BIRTH

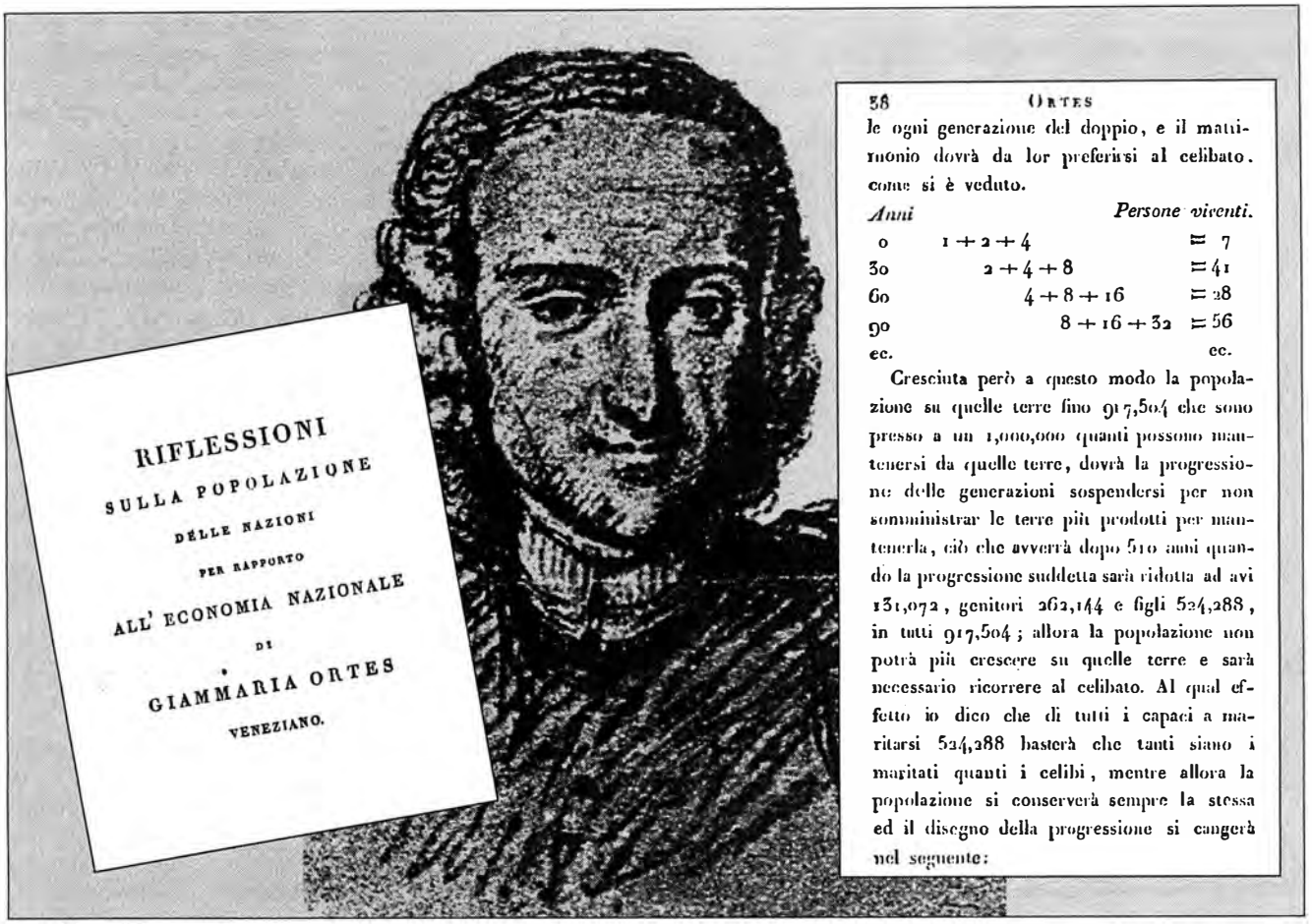


All charts are based on standard estimates compiled by demographers. None claims any more precision than the indicative; however, the scaling flattens out what might otherwise be locally, or even temporally, significant variation, reducing all thereby to the set of changes that is significant, independent of the quality of estimates and scaling of the graphs. Note breaks and changes in scales.

Sources: For population and population-density, Colin McEvedy and Richard Jones, *Atlas of World Population History* (1978); for life-expectancy, various studies in historical demography, including Gy. Acsádi and J. Nemeskéri, *History of Human Life Span and Mortality* (1970); Peter R. Cox, *Demography* (1976); Jacques Dupâquier, *La population rurale du Bassin parisien á l'époque de Louis XIV* (1979); Jacques Dupâquier, *Introduction á la démographie historique* (1974); D.V. Glass and D.E.C. Eversley, eds., *Population in History* (1965); T.H. Hollingsworth, *Historical Demography* (1965); Roger Mols, S.J., *Introduction á la démographie historique des villes d'Europe du XIVe au XVIIIe siècle,* (1955); Henry S. Shryock et al., *The Methods and Materials of Demography* (1976); E.A. Wrigley, *Population and History* (1967); E.A. Wrigley and R.S. Schofield, *The Population History of England, 1541-1871* (1981).

Table 1
THE DEVELOPMENT OF HUMAN POPULATION

	Life expectancy at birth (years)		Population density (per km²)	Comments	World population (millions)
Primate Comparison					
Gorilla			1/km²		.07
Chimpanzee			3-4/km²		1+
Man					
Australopithecines B.C. 4,000,000-1,000,000	**14-15**		**1/ 10 km²**	68% die by age 14	**.07-1**
Homo erectus B.C. 900,000-400,000	**14-15**				**1.7**
Paleolithic (hunter-gatherers) B.C. 100,000-15,000	**18-20+**		**1/ 10 km²**	55% die by age 14; average age 23	
Mesolithic (proto-agricultural) B.C. 15,000-5,000	**20-27**				**4**
Neolithic, B.C. 10,000-3,000	**25**		**1/km²**	"Agricultural revolution"	**10**
Bronze Age B.C. 3,000-1,000	**28**		**10/km²**	50% die by age 14 Village dry-farming, Baluchistan, 5000 B.C.: 9.61/km² Development of cities: Sumer, 2000 B.C.: 19.16/km² Early Bronze Age: Aegean, 3000 B.C.: 7.5-13.8/km² Late Bronze Age: Aegean, 1000 B.C.: 12.4-31.3/km² Shang Dynasty China, 1000 B.C.: 5/km²	**50**
Iron Age, B.C. 1,000	**28**				**50**
Mediterranean classical period B.C. 500-A.D. 500	**25-28**		**15+/km²**	Classical Greece, Peloponnese: 35/km² Roman Empire: Greece: 11/km² Italy: 24/km² Asia: 30/km² Egypt: 179/km²* Han Dynasty China, B.C. 200-A.D. 200: 19.27 Shanxi: 28/km² Shaanxi: 24/km² Henan: 97/km²* Shandong: 118/km²* * Irrigated river-valley intensive agriculture	**100-190**
European medieval period 800-1300	**30+**		**20+/km²**	40% die by age 14 Italy, 1200: 24/km² Italy, 1340: 34/km² Tuscany, 1340: 85/km² Brabant, 1374: 35/km²	**220-360**
Europe, 17th century	**32-36**			Italy, 1650: 37/km² France, 1650: 38/km² Belgium, 1650: 50/km²	**545**
Europe, 18th century	**34-38**		**30+/km²**	"Industrial Revolution" Italy, 1750: 50/km² France, 1750: 44/km² Belgium, 1750: 108/km²	**720**
Massachusetts, 1840		**41**			
United Kingdom, 1861		**43**	**90+/km²**		**1,200**
Guatemala, 1893	**24**				
European Russia, 1896	**32**				
Czechoslovakia, 1900		**40**			
Japan, 1899		**44**			
United States, 1900		**48**			
Sweden, 1903		**53**			
France, 1946		**62**			
India, 1950	**41**				**2,500**
Sweden, 1960		**73**			
1970	Pre-industrialized	Industrialized		Population density figures are for 1975.	**3,900**
United States		**71**	26/km²		
West Germany		**70**	248/km²		
Japan		**73**	297/km²		
China	**59**		**180/km²**		
India	**48**		183/km²		
Belgium			**333/km²**		



Not only is Arrow's idea of "carrying capacity" all wrong, but it is plagiarized from the 18th century Venetian monk Giammaria Ortes (1713-1790). Here, a drawing of Ortes along with some population figures from his 1790 work, in which he attempts to show that the rate of population increase will outpace the capacity of the land.

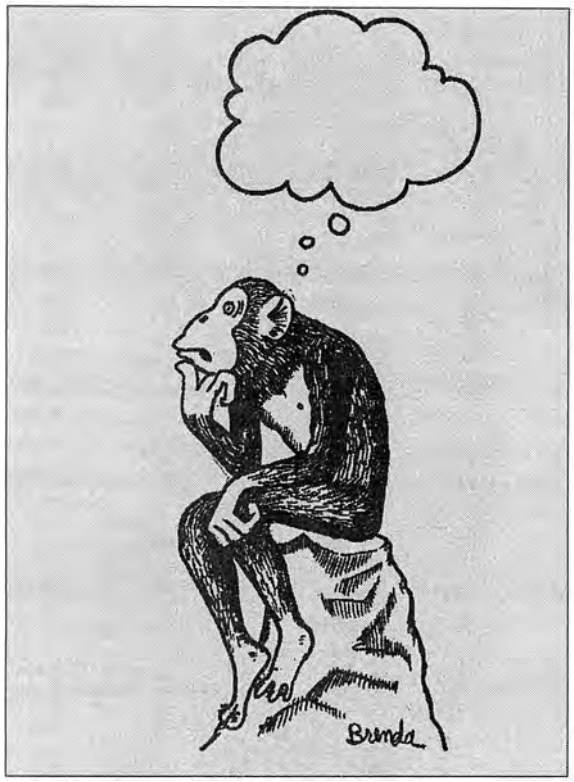
ters is the content of growth—the composition of inputs (including environmental resources) and outputs (including waste products). This content is determined by, among other things, the economic institutions within which human activities are conducted. These institutions need to be designed so that they provide the right incentives for protecting the resilience of ecological systems. Such measures will not only promote greater efficiency in the allocation of environmental resources at all income levels, but they would also assure a sustainable scale of economic activity within the ecological life-support system. Protecting the capacity of ecological systems to sustain welfare is of as much importance to poor countries as it is to those that are rich.

The reader is challenged: Can you identify relevant measurements, which might be made to demonstrate the truth or falsehood contained within that paragraph which we have just quoted? How is "economic activity" to be measured? In what units, do we measure "carrying capacity"? In what units, might one measure "resilience." If one cannot identify such measurements, what meaning could anyone attribute to the formulation: "*greater efficiency* in the *allocation* of environmental *resources* at *all income levels* . . ." which "would ensure a *sustainable scale of economic activity* within the ecological life-support system"? In what units, should one measure *greater efficiency, sustainable scale of economic activity, resources, income levels?* What kind of an *allocation* function, will be employed for this purpose? Nowhere in the

Sources for Table 1: For world population and population densities, McEvedy and Jones, *Atlas of World Population History* (1978), and Colin Clark, *Population Growth and Land Use* (1967). For primate comparison, estimates presented by George B. Schaller, *The Year of the Gorilla* (1965). For life-expectancies: for prehistoric man through the European medieval period, Acsádi and Nemeskéri, *op. cit.*, and Kenneth M. Weiss, *Demographic Models for Anthropology* (1973); for Bronze and Iron Ages, additionally J. Lawrence Angel, "The Length of Life in Ancient Greece," *Journal of Gerontology*, Vol. 2, Nos. 1-4 (1947); for classical period, additionally J.C. Russell, "Late Ancient and Medieval Populations," *Transactions of the American Philosophical Society*, New Series, Vol. 48, No. 3 (1958); for 17th and 18th centuries, Wrigley and Schofield, *op, cit.*, and Glass and Eversley, eds., *Population in History* (1965); for 19th and 20th centuries, Weiss, *op. cit.*, and T.E. Smith, "The Control of Mortality," *Annals of the American Academy of Political and Social Science*, Vol. 369 (Jan. 1967). For area studies: for Mesopotamia, Robert J. Braidwood and Charles A. Reed, "The Achievement and Early Consequences of Food-Production," in *Cold Spring Harbor Symposia on Quantitative Biology*, Volume XXII (1957); for the Aegean, Colin Renfrew, *The Emergence of Civilization: The Cyclades and the Aegean in the Third Millennium B.C.* (1972); for the Peloponnese, Clark, *op. cit.*; for the Roman Empire, Karl A. Wittfogel, "The Hydraulic Civilizations," in *Man's Role in Changing the Face of the Earth*, ed. by William L. Thomas, Jr. (1956); for China, John D. Durand, "The Population Statistics of China, A.D. 2-1953," *Population Statistics*, Vol. 13, No. 3 (March 1960).

article are there hints as to the nature of the units or functions required.

Let us identify some of the anomalies of measurement those authors would have been obliged to resolve, had they wished to contribute a lucid argument on the topics they name. Let us begin with the notion of "carrying capacity," which they have borrowed—perhaps unwittingly—from old Giammaria Ortes. For the following discussion of this matter, reference both Figure 1 "Growth of European Population,"[14] and Table 1 "Development of Human Population."[15]



For our purposes here, it is sufficient to argue that today's contention among relevant paleontologists is, that the human species may have existed on this planet for as long as 2 million years, or perhaps less. If we apply known evidence to that presumption, we have that general picture of changing human demography and growth of population-density which is summarized by the combined images of Figure 1 and Table 1.

Three dimensions of the process must be considered, to represent the process implicitly described by those indicated changes in the population-density. All parameters of change in combined demography and population-density, must be stated as values per unit of land-area utilized, per household, and per capita. The latter, per capita assessment, applies to the total population's imputable, total labor-force, or equivalent function.

To arrive at useful statements respecting changes in population-density, we must correlate those changes, with changes in demographic characteristics of households, labor-force members, and total population. To address matters such as those which were named by Arrow et al., we must define the relationship between measurable features of population-density and demography, and "economic growth," respectively. We must discover some ontological, not merely statistical correlation—or lack of correlation—between the two arrays. Since we are comparing modern with very ancient societies, it should be indisputable, that we must measure "economic growth" in terms which do not depend upon the existence of a monetary-financial system. We must resort to the methods of the science of *physical economy,* as developed by Gottfried Leibniz over the interval 1671-1716.[16]

Therefore, to obtain a useful, first-approximation measurement of "economic growth," a self-respecting operations researcher would have wished to construct a good descriptive model. For reasons which ought to be implicitly obvious, such a conscientious inquirer would begin with a relatively simple, easily defined, undergraduate-classroom sort of "thermodynamical," input-output model.

In first approximation, such a researcher would define the relevant "inputs" of consumption, required to sustain that population at levels of both demographic characteristics and population-density, which are equal to or greater than those previously extant. Let us regard this as comparable to the classroom notion of "energy of the system." The researcher would wish to compare these quantities of those qualities of consumption, considered as inputs, with the society's reproduction of output of the same, or better qualities. The gain of that output over the required input, thus represents relative "free energy" of the physical-economic process. We measure the ratio of the "free energy" of that process to its "energy of the system." If the "free energy" is successfully converted into an increase of the "energy of the system," and without decreasing the ratio of "free energy" to "energy of the system," we have the case which conforms approximately to the picture presented in Figure 1 and Table 1. So, the notion of "growth" to be employed for the inquiry proposed by Arrow et al., requires that the functional relationship between output and input not be entropic in form.

The question posed by Norbert Wiener's and John von Neumann's axiomatic assumptions, is whether or not the growth of economies, as measured in the terms just described, is not a "local reversal of entropy," in the sense of Ludwig Boltzmann's derivation of his statistical H-theorem.[17] Or, in the alternative, does such economic growth in society lessen the estimable entropy of the universe at large? During recent years, it has become fashionable among radical "ecologists" to argue, in effect, that, "according to the Second Law of Thermodynamics," the entropy of the universe as a whole, and the system of planet Earth locally, must increase; "*therefore!*," their hand-waving rhetoric continues, "the increase of the 'negentropy' of society could occur only by accelerating the entropy of the planet and universe as a whole." No proof has been supplied for their assertion; but that slight imperfection in their rhetoric has not lessened the passion with which the proposition is asserted. As we shall see, below, the contrary proposition is the demonstrable case.

At this point, let us abandon all further use of the term "negentropy" from our discussion of living systems in general, or human behavior. Let us use a term which bears none of the ideological baggage of Wiener's "information theory" dogma; let us use the term "not-entropy" in the following way. Economic "not-entropy" corresponds to a process, or phase of a process, in which the *energy of the system* increases per capita, per household, and per unit-area of land utilized, in

which the ratio of *free energy* to *energy of the system* remains constant or increases.

In respect to the proposition which Arrow et al. purport to have addressed, the study of "not-entropy" in economic growth should be applied, first, to the economic process, narrowly defined as such, and, after that, to the interaction between a "not-entropic" state of the economic process and the "environment" within which that economic process is located. One might see, rather quickly, that some crucial facts are to be learned from focussing, at first, more narrowly, on the internal dynamics of the physical-economic process as such.

After that first phase of the inquiry, once the two phases of the process are seen in a combined way, it will become clear why the notion of "carrying capacity" introduced by Ortes was always absurd, and remains so today. Had Arrow et al. troubled themselves to state their proposition in terms of measurable magnitudes and related notions of functions, they would have discovered, that their notions of "economic growth," "carrying capacity," and "resilience" are absurdities.

Measuring Economic 'Not-Entropy'

The key fact upon which a science of physical economy is premised, is the demonstration, that the coordinate variability of society's demographic and population-density characteristics has no precedent in other living species. To some observers, in every respect but the human individual's intellectual potentials, man is plausibly a higher ape: a higher-primate omnivore of food-gathering capabilities which may be fairly compared with the stronger and hairier varieties of higher apes. Yet, had mankind been a higher ape, at no time during the recent 2 million years, would the human population have exceeded several million living individuals.

The actual growth of the human population, and the demographic improvements associated with that, is the primary referent for the use of the term "economic growth" in physical economy. This term implicitly references the fact, that inferior species of life have a degree of adaptability which sets upper bounds for the potential relative population-density of each species. This estimable, "ecological" upper bound is associated with the characteristics of species and varieties among those species. It would be an exaggeration to state that this variability is "genetically" fixed, although, in the narrow sense, and short-term, that might appear to be the case to the presumptuous observer.

It should not be necessary to re-argue the obvious point here, that the cultural history of mankind shows that this factor in economic growth is not automatic, but is *willful*. By the very fact that Arrow et al., among others, occupy themselves with discussing something as willful as changes in existing economic policy, they have implicitly abandoned the basis for objecting to our view of this factor of difference as a voluntary one, not as "instinctually" predetermined. This discrepancy between human and animal ecologies—this crucial anomaly—prompts us to ask: How might this functional difference be measured? Failure to address that crucial point invalidates any "environmentalist" criticism of a traditionalist policy of modern civilization, the policy of scientific and technological progress for its own sake. Bernhard Riemann's famous 1854 habilitation dissertation provides an axiomatic key for meeting that challenge.[18]

"Had mankind been a higher ape, at no time during the recent 2 million years would the human population have exceeded several million living individuals."

We are now at the outset of the most crucial point of that scientific argument which must be addressed, before any competent policy-theorems on so-called environmentalist issues could be presented. This is the crucial point which all of the visible co-thinkers of the Club of Rome, Laurance Rockefeller, and IIASA[19] have variously refused or failed to address over the 27-year span of the U.S. "environmentalist movement" 's existence in its own name.[20]

Since any deductive mathematical system is derivable from a geometry, the passage from one geometry to a relatively higher one, is the most general form of mathematics suited for addressing those problems of measurement implicitly posed by the conjectures within the article presented by Arrow et al. Riemann's habilitation dissertation is an exemplar of the entry into those qualitatively higher domains of mathematics in general.

The notable point to be stressed again, as Riemann emphasizes this dramatically at the conclusion of his habilitation dissertation: the point at which we pass from ordinary mathemat-

14. Adapted from *Fidelio*, Vol. III, No. 3, Fall 1994, p. 25.
15. Adapted from *Executive Intelligence Review*, Vol. 22, No. 12, March 17, 1995, p. 23.
16. Two of the present writer's books on physical economy are most relevant for this purpose. His introductory textbook, *So, You Wish to Learn All About Economics* (New York: New Benjamin Franklin House, 1984), and *The Science of Christian Economy* (Washington, D.C.: Schiller Institute, 1991).
17. See Morris Levitt, 1976. "Linearity and Entropy: Ludwig Boltzmann and the Second Law of Thermodynamics," *Fusion Energy Foundation Newsletter*, September, pp. 3-18.
18. Bernhard Riemann, 1854. *"Über die Hypothesen, welche der Geometrie zu Grunde liegen,"* ["On the Hypotheses Which Underlie Geometry"] *Bernhard Riemanns Mathematische Werke*, H. Weber, ed. (New York: Dover Publications, 1953), pp. 272-286. An English translation appears in David E. Smith, *A Source Book in Mathematics* (New York: Dover Publications, 1959).
19. IIASA: The Laxenberg, Austria-based International Institute for Applied Systems Analysis. This was set up by the same British intelligence team which launched the Club of Rome. That team included Britain's Dr. Alexander King, who described his co-creation, the Club of Rome, as motivated by a wish to shrink the darker-complexioned populations of the Mediterranean, Africa, and Asia. King had been a key figure in the destructive educational programs launched through the Paris office of OECD in 1963. This team also included, most prominently, Lord Solly Zuckerman (the "baboon man" from South Africa).

    According to King, he, Zuckerman, and Soviet official Dzherman Gvishiani (Soviet President Kosygin's son-in-law) set up IIASA as a KGB channel of the Club of Rome into Moscow. IIASA served as a conduit for the influence of Cambridge University's "Systems Analysis" group around Lord Kaldor; the Moscow end of the connection was I. Frolov's Global Systems Analysis group.
20. For the information of those who, unlike the present writer, were not "on the ground," when the U.S. environmentalist movement was assembled from such relics of 1968 as the shattered SDS: What became the mass-based U.S. environmentalist movement of today, was set into motion during the second half of 1969; the mass organizing which established that movement was completed during the first half of 1970.

ics into these higher, subsuming considerations, is a matter lodged within a domain higher than mathematics itself, that of physics. In this case, what Riemann says of physics in general, must be focussed upon the domain of physical economy. This is the domain we reference here, to address the problem of measurement which is posed by that seemingly anomalous, unique characteristic of human existence, which sets the economic processes of society apart from, and above the domain of animal ecology.

For our narrowly defined purpose here, the following approximation of the required measurement is adequate.

If we assume, that the limited range of potential adaptability by any variety of a lower animal species, can be treated, in approximation, as genetically determined, then, that range of behavioral adjustment can be regarded as, approximately, a formal theorem-lattice of those behavioral propositions which are valid for that variety of that species. This assumption simplifies the task of describing, in effect, the difference which places human behavior and population-potential absolutely apart from, and above that of any animal species.

If this imagery is valid, then it must be the case, that the ability of the human species to rise to today's population-densities, more than three decimal orders of magnitude greater than that imputable to an aboriginal, ape-like food-gatherer, may be represented as a series of theorem-lattices, which are each axiomatically distinct from one another, arranged in an order corresponding to increase of potential relative population-density.

We must then ask ourselves: Is the result of such a "meta-mathematical" description a mere ruse of "operations research model-making," or does this model correspond to a characteristic feature of the actual physical-economic process? Our response is a definite, if *ontologically* qualified, "the latter." The obvious first step is to demonstrate that for mathematical science; after that, the same point must be demonstrated for the fine-arts media, too.

To describe the demonstration for mathematical science, begin with the following reformulation of Riemann's habilitation dissertation. To some, what is now provided may appear as a digression. Let them be calmed: it will be shown that none of this is digression. These passages will make clear, not only what the most crucial blunder of Arrow et al. has been, but why the consenters to their article bungled the issue as they did.

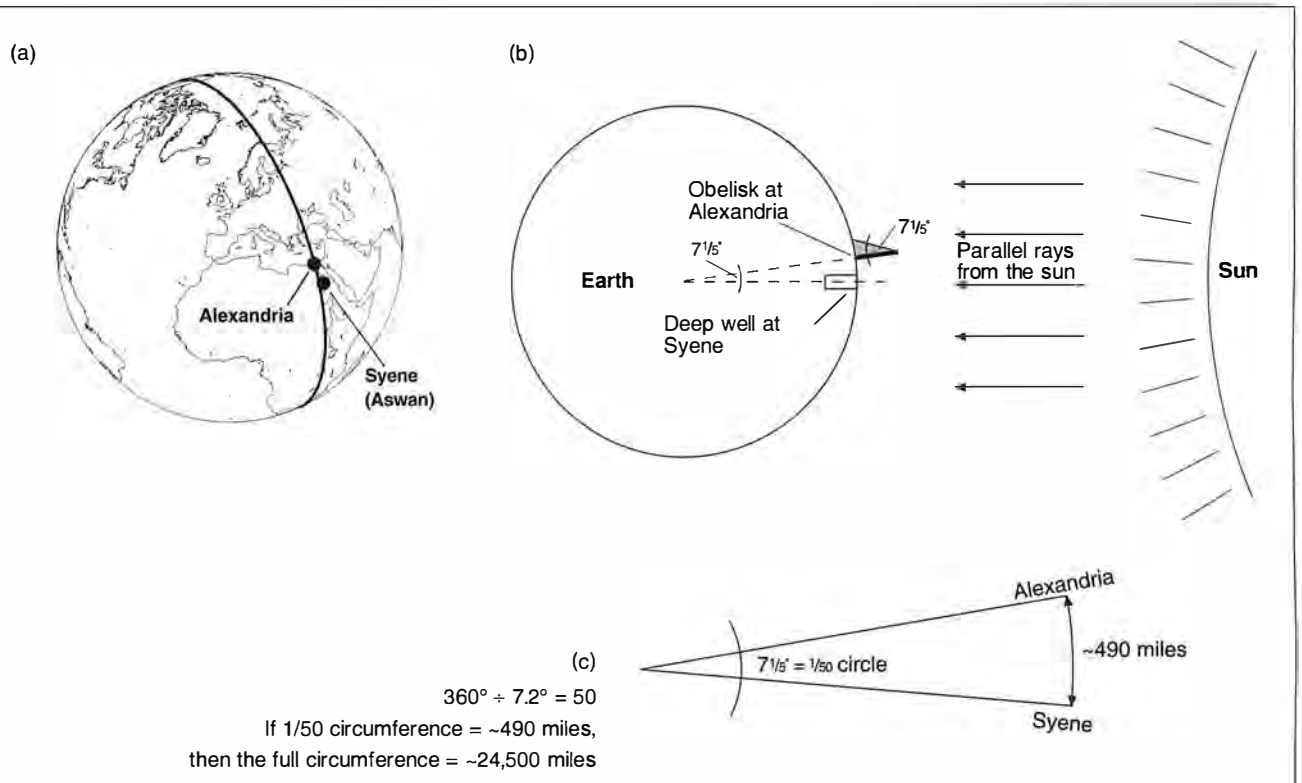


Figure 2
HOW ERATOSTHENES MEASURED THE UNSEEN

Eratosthenes' measurement of the size of the Earth was based upon determining the angle of arc between Alexandria and Syene (Aswan), cities that lie close to the same meridian at a walking distance of approximately 490 miles (a). At the same time that the Sun's rays shone directly into a deep well in Syene, they cast a shadow of 7.2° from the top of an obelisk at Alexandria (b).

Eratosthenes' calculation was remarkably accurate.

Source: Adapted from "What Is God That Man Is in His Image?" by Lyndon H. LaRouche, *Fidelio,* Vol. IV, No. 1, Spring 1995, p. 28.

Axiomatic Method

What was taught traditionally as "geometry," was not a true sensory image of the arrangement of events in real physical space-time, but was, rather, a creation of the naive visual imagination. Empty space was defined, in the imagination, as extended, without limit and with perfect continuity, in three senses of direction: backward-forward, up-down, and side-to-side. It was imagined, similarly, that sense of time was backward-forward. This was assumed to be space-time.

Physics was assumed to be the placing of movable objects within this empty, "Euclidean" space-time, noting their position and displacement in much the same way the analytic geometry of René Descartes prescribes. The assignment of ponderability, percussive interaction, and action-at-a-distance, formed the initial basis of what clicked in many mechanical minds as a mathematical physics: a parody of Aristotle and pre-Aristotelian reductionists generally.

That naive notion of Euclidean space-time corresponds neither to our sense-perceptions, nor to any demonstrable form of physical reality. Leonardo da Vinci demonstrated that space is harmonically organized, not simply continuously extended, and that vision affords us no evidence that extension in space-time is perfectly continuous in any sense. As Johannes Kepler, Leibniz, Riemann, and later Max Planck showed, physical space-time is quantized, not continuously extended simply.

The naive picture began to be challenged most profoundly, beginning with the appearance of Nicholas of Cusa's *De docta ignorantia,* in 1440; among his profound accomplishments there, Cusa was the first to locate within the mathematical domain of "incommensurables," a higher order of magnitude, known today as "transcendentals."[21] This work of Cusa, and of Leibniz, et al. on what we know as "transcendentals," is key to Riemann's fundamental discovery of 1854. Notable are those 1690s' works of Leibniz, J. Bernoulli, and others, following the discoveries of Ole Rømer and Christiaan Huygens, on the brachystochrone characteristics of the refraction of light propagated at a finite speed. These considerations typify the demonstration, that certain unique phenomena of physics, being at once undeniable and also in defiance of the axiomatic principles of a pre-established mathematical-physics doctrine, force an overturn of at least some among the essentially underlying axiomatic assumptions of pre-established doctrine.[22]

In the case of the treatment of non-algebraic physical functions by Leibniz, it was the naive space-time geometry of Galileo, Descartes, and Newton—as we identified this summarily just above—which was discredited by the physical evidence. The relevant point is made clearer, if we restate the same issue in different terms of reference.

A voluntary choice of a change in behavior, for the case that behavior and its results have never been experienced earlier, is an action which lies within the domain, not of experience, but of the imagination. The associated difficulty with such voluntary powers, is that, although the scope of the imagination of the individual person is potentially vast, this vastness extends into previously unexperienced states of nature, some of which prove later to exist, and other unexperienced states which do not exist. Thus, the characteristic problem of the imagination, is the task of distinguishing between the two kinds of results: the true, or possible, and the impossible.

Consider the peril which, on the one side, attends a risky experiment, and the sometimes greater peril which attends avoiding that risk; humanity requires an appropriate means for foreknowledge of the quality of a result before that result could be tested by experience. Thus, the quality of *science* cannot be anything other than a reliable quality of *prescience.* Consider what I have come to adopt, in recent times, as my favorite demonstration of the point to be made now: Eratosthenes' estimate of the length of the meridian passing through the poles of the Earth; this is the kind of demonstration of what Plato signifies by "ideas," which any literate adolescent could readily comprehend.

Eratosthenes estimated the size of what he presumed to be that circular meridian to within approximately 50 miles of the actual polar diameter (Figure 2). The construction is one which a team of literate adolescent pupils could rather readily understand and replicate; the point is, that Eratosthenes measured the curvature of the Earth about 2,200 years prior to the time any human being had seen the curvature of the Earth.[23] Like Thales earlier, and in the tradition of the Platonic Academy of which he was a product and part, Eratosthenes shows afresh the *efficiency,* for human social practice, of ideas which rest not upon sense-perceptions, but upon anomalies among sense-perceptions.

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21. The conventional, mistaken view, is that associated with Professor Felix Klein, who argued, that the proof of the transcendental quality of *pi* was first demonstrated by Ferdinand Lindemann, following Charles Hermite on natural logarithms, in 1882. Cusa's proof, based upon a correction of Archimedes' method, was already conclusive geometrically. The same issue arose, in a related way, in Gottfried Leibniz's physics-referenced differentiation between algebraic and non-algebraic (transcendental) functions. The work of Hermite is an elegant accomplishment in its own right; however, the principled, axiomatic issues were already settled by Cusa, by Leibniz after him, and were also generally understood by the tradition of Gaspard Monge and A.M. Legendre in France, and of Karl Gauss.

    In this matter of the "transcendence of *pi*," Klein's misrepresentation has significant origins, origins with rather devastating implications for the practice of mathematics today. Klein's fraudulent assertion on this matter, is a consequence of a long, unfortunate tradition in the Berlin Academy and its successors, dating from the time of Prussia's Frederick II. The origin is specifically a series of fraudulent attacks upon Leibniz by the Conti salon's agents, including, notably, "least-action affair" hoaxster Pierre-Louis Maupertuis and his leading accomplice, the extraordinarily talented, but morally perverse Leonhard Euler. [On Euler's politically motivated attack on Leibniz, see Lyndon H. LaRouche, Jr., "Euler's Fallacies on the Subjects of Infinite Divisibility and Leibniz's Monads," *The Science of Christian Economy* (Washington, D.C.: Schiller Institute, 1991), pp. 407-425.] It was Euler, through the Berlin Academy's Johann Lambert (1768), who generated the anti-Leibniz, algebraic approach later continued by Hermite and Lindemann. This is the tradition of fraud which the politically sensitive, pro-Hegelian Klein defends by his exaggerated claims for Hermite and Lindemann.

22. In that way, Leibniz had already overturned axiomatically the mechanistic mathematical physics of Paolo Sarpi protégé Galileo Galilei, René Descartes, and Antonio Conti protégé Isaac Newton, to such effect that from the 1690s until the dismantling of the Monge Ecole Polytechnique, in 1815, Newton's reputation survived only in those circles which represented the direct, continuing Venetian influence of Antonio Conti's 18th century salons. Exemplary of this is the Berlin Academy under Prussia's Frederick II; the scandal which exposed Pierre-Louis Maupertuis and Leonhard Euler as hoaxsters, in the "least action affair," typifies the control of science at that Academy by such Antonio Conti creatures as Algarotti, Maupertuis, and Voltaire. The LaPlace appointed to wreck the Ecole Polytechnique of Monge and Legendre, reestablished the influence of the previously discredited Newton in France.

23. *Greek Mathematical Works*, 1980. 2 vols. Loeb Classical Library. Ivor Thomas, trans., Vol. II (Cambridge, Mass.: Harvard University Press), pp. 266-273.

Let us designate validated *ideas* of that distinctively Platonic quality as characteristically products of a special human intellectual capability, absent in the beasts, which we shall agree to name *creativity*. Let us add a further restriction. Define a creative act in mathematical physics, or another department of physical science, as any anomalous, but valid *idea* which requires a change in that underlying set of axiomatic assumptions which defines the pre-existing body of formal knowledge, relatively, as a consistent theorem-lattice. That establishes the bearing of this matter upon the describable difference between the economic behavior of the human species, and the ecological characteristics of the lower species.

"The singularities of mathematical physics are the poetry of physical science, the characteristic footsteps, the metaphors, or true creativity, as expressed within the medium of that latter domain."

Such validatable creative acts of the imagination, as found within the domain of the mathematical physical sciences, have a readily identifiable complement within the domain of the classical fine arts. In the mathematical domain, any such change in axiom defines a formal mathematical discontinuity, or singularity, separating the previous theorem-lattice from the superior one. In the case of creativity in the fine arts, the role of the mathematical discontinuity is filled by the *metaphor*.[24] Conversely, we could say truthfully, that the singularities of mathematical physics are the poetry of physical science, the characteristic footsteps, the metaphors, of true creativity, as expressed within the medium of that latter domain.

Consequently, when we speak, after Riemann, of an apparently "self-bounded" physical space-time, we have left the domain which empiricism adopts as "objective evidence"; these bounds are known to us in the domain of what Plato defines as "ideas." They are what valid discoveries have shown to us to be the boundary which divides the imagination into two regions: the first, the portion of the domain of imagination which corresponds to valid discoveries, and that other portion which does not. The fact, that this boundary exists in the subjective domain, rather than the so-called "objective" realm of the empiricists, does not diminish its reality, but rather enhances it. We are speaking of those changes which the valid crucial discoveries of principle, from the domain of physics, instruct us to impose, from the exterior, upon our notions of geometry. This externally imposed alteration of geometry is the price we must pay, if we are to develop a sane mathematical physics, a mathematical physics which responds to the accumulated evidence from valid axiomatic-revolutionary discoveries. We require a "meta-mathematical" physics which efficiently guides us to distinguish the boundary separating the valid from the invalid regions of the imagination.

Education and Economy

Arrow et al. should have examined these distinctions, which we have just referenced, from the standpoint of the contrast between two educational methods. The first, the unfortunately commonplace, textbook method of classroom instruction; the second, the classical-humanist, or Socratic method. In the first, the student assimilates approved doctrines; in the second, the student's educational experience is pivotted on reliving the act of original discovery of one crucial discovery after another. The latter mode of education provides a paradigmatic image of the kind of social process which is occurring in a society in which the productive powers of labor, per capita, per household, and per unit of land-area, are being increased through the impact of capital-intensive, energy-intensive investment in scientific and technological progress.

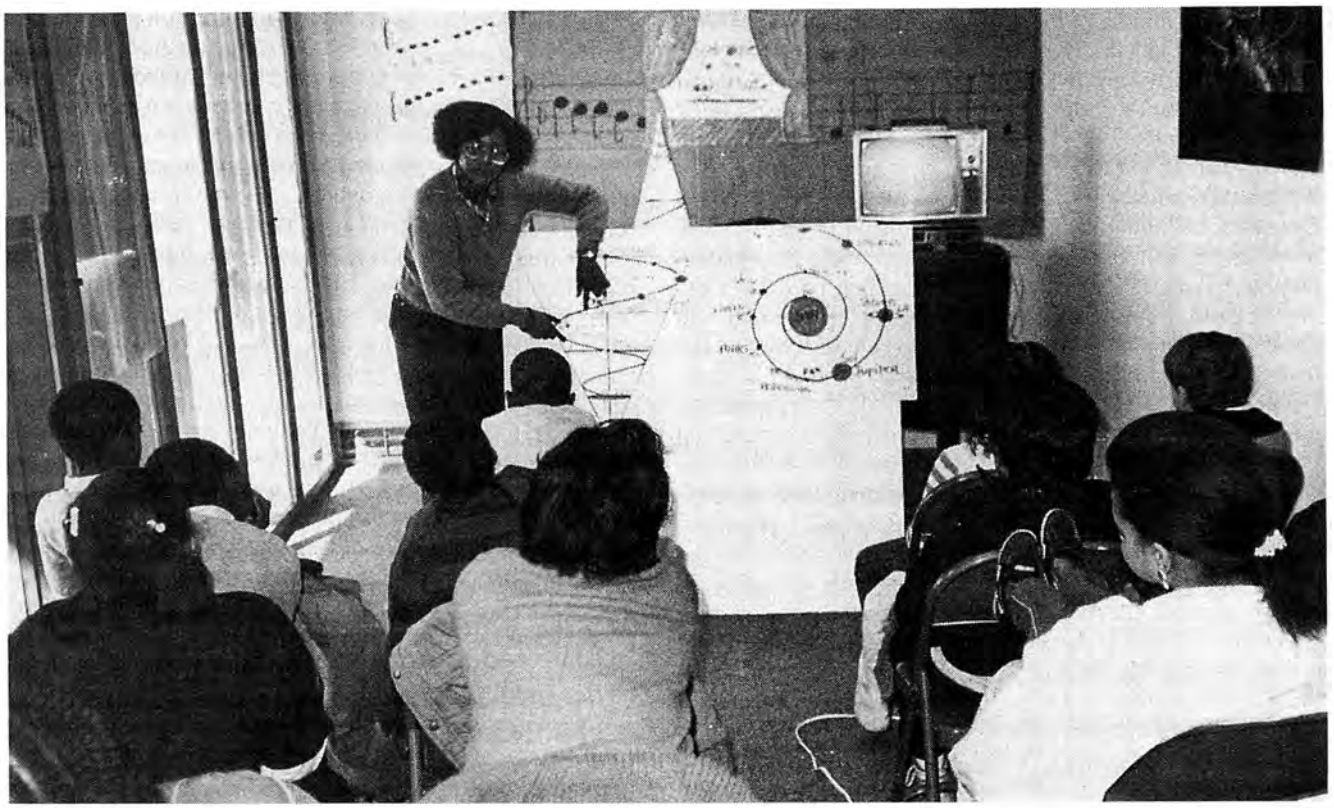
Assume the case, that a secondary school graduate, at about the age of 17 years, has benefitted from a classical-humanist (Socratic) mode of education.

Through the numerous creative discoveries (each, initially, original to the infant, child, or adolescent) which are relived in the process of growing up and being educated, the pupil has assimilated much of the most crucial portion of the cultural heritage of mankind up to that time. He has experienced, thus, the original, axiomatic-revolutionary discoveries embodied in the development of the language and its use, in the development of plastic and non-plastic fine arts generally, and in the ideas of science and technology. The student has accumulated an enormous number of axiomatic-revolutionary discoveries, each, in its turn, a discontinuity in the succession of theorem-lattice-like bodies of knowledge to date. Progress, thus, in effect, assumes the form within that graduate's mind, of an increase of the density of (axiomatic-revolutionary) discontinuities per interval of thought-action by that student's mind.

We cannot assign any simple kind of measurement to that transfinite overview of the student's mental processes; but, the idea of measurement is clearly defined, nonetheless.

Carry that graduate's education, then, and, later, after a university education, over to the processes of production of wealth. What is the connection among an axiomatic-revolutionary quality of scientific discovery, technology, and increase of the productive powers of labor in that society? How does the mind of that student, or former student, interact with that process of increasing the productive powers of labor? To address this, focus upon the crucial type of case: those unique qualities of valid discoveries of principle, the which are fairly represented, from the vantage-point of formal theorem-lattices, as axiomatic-revolutionary advances in scientific knowledge.

Such a crucial, new proposition demands "proof of principle" experiments, or observations to the same effect. The refinement of successful experiments (or, observations) of that function, brings us to the point, that a successful laboratory apparatus provides the model of reference for the introduction of a new machine-tool principle to the productive, or analogous processes within the economy. That newly developed machine-tool, or analogous principle, represents what is usefully and fairly identified as a "new technology." The incorporation of sundry applications of that new technology to designs of products, of production processes, and of the human environment, typifies what U.S. Treasury Secretary Alexander Hamilton identified as the role of investment in "artificial labor" to the effect of increasing the "productive powers of labor."[25]



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Here, students in Chicago looking at the similarities of the geometry of solar system orbits and the registration of the human voice.

The investment in such (and related) new technologies, combined with the spread of those ideas which correspond to the impact of the same discoveries of principle, provide us the most readily identified feature of the relationship between scientific and technological progress, and those increases of the productive powers of labor which account for the results depicted in Figure 1 and Table 1, above.

The same point is to be made for great works of classical fine art. In both types of creative work, scientific discovery and composition of great fine art, the successful creative act appears in the guise of a metaphor. In mathematical physics, as a formal mathematical discontinuity, or singularity; in art, as metaphor. Both are different ways of representing the same activity. In each instance, the metaphor stands for that which is not susceptible of a literal meaning within that existing language within which the metaphor (or, discontinuity) is situated.[26]

When we examine the accumulation of valid changes in the state of human knowledge, in terms of that process's most crucial, axiomatic-revolutionary incidents, we should recognize that our use of the principle of formal theorem-lattices to identify the qualitative difference of man from beast, is no mere model-maker's convenience. The axiomatic-revolutionary event, the discontinuity which separates one theorem-lattice from the better theorem-lattice which supersedes it, sets the mark which is typical of that series of incidents, the which sets the demography and population-density of historical human existence apart from the relevant characteristics of animal ecology.

The process marked by that series of axiomatic-revolutionary events, is the manifest origin of the societal impulse for what we identified, above, as the "not-entropy" manifest in economic growth. To complete that picture, we must examine the interaction between that "not-entropic" impulse within society, and the constraints which that impulse must overcome to provide a sustainable increase of the "energy of the system" per capita, per household, and per unit-area, under the condition that the ratio of "free energy" to "energy of the system" not decrease.

Consider first, the constraints bearing upon the development of the potential for economic growth within the population; then, second, consider the constraints expressed in the relationship between that population and its environment.

Look, now, at the broadly definable role of education itself, considered as a constraint of such an impulse. Turn again to focus upon the growth of the modern European population-density (Figure 1), 1500-1975. Concentrate upon the graphs for "population-density" and "life-expectancy."

24. See the *Fidelio* "Metaphor" series by Lyndon H. LaRouche, Jr.: "On The Subject of Metaphor," Fall 1992; "Mozart's 1782-1786 Revoution in Music," Winter 1992; "On the Subject of God," Spring 1993; "History As Science," Fall 1993; "The Truth About Temporal Eternity," Summer 1994.
25. See (U.S. Treasury Secretary) Alexander Hamilton, *Report to the U.S. Congress on the Subject of Manufactures*, Dec. 1791. Excerpts appear in *Executive Intelligence Review*, Jan. 3, 1992, pp. 6-14. Hamilton's notion of "artificial labor," like the anti-Locke "general welfare clause" in the Preamble of the U.S. Federal Constitution, represents the influence of Gottfried Leibniz on the principal architects, such as Benjamin Franklin, of the American Revolution and U.S. Federal Constitution of 1789.
26. Hence, the intrinsic, ontological absurdity of Wiener's attempt to measure the content of "information" in terms of Boltzmann's H-theorem.

During the middle of the 15th century, from approximately 1430, until 1483, a dramatic institutional change occurred within Western Europe's leading institutions, the Catholic Church and France under Louis XI: the "Golden Renaissance," centered upon the 1439-1440 developments at the Council of Florence, and Louis XI's founding of a reconstructed France as the first modern nation-state, the forerunner of our U.S. Federal Constitutional Republic. The radiated impact of these institutional changes brought about rates of improvement in demographic characteristics of populations which had never occurred earlier, during all human existence, as Figure 1 and Table 1 illustrate that point. The development which underlies both the making of the "Golden Renaissance," and the establishment of Louis XI's France as the first modern nation-state, is the limited, but crucial influence of the secondary-educational programs of the Brotherhood of the Common Life. Without focussing upon the influence of that educational program, there could be no rational comprehension of either the Golden Renaissance, nor the founding of the modern nation-state, nor the recent centuries' unprecedented improvements in the condition of the population within extended European civilization.

The key to these improvements is located in the rate of generation of new not-entropic impulses, and the rate at which those are assimilated by the population. It is the assimilation of the impact of axiomatic-revolutionary progress in ideas, within the population in general, which sets the upper boundaries upon the potential for that quality of "economic progress" which we have referenced here. The difference which accounts for the relatively sustained, hyperbolic improvement of demographic characteristics and population-densities of populations under European civilization, during the recent 550 years, is chiefly twofold. First, the commitment of society in the direction of providing universal education, according to the impulse supplied by institutions such as the Brotherhood of the Common Life. Second, the emergence of the modern nation-state as an institution committed to fostering sustained rates of increase of the productive powers of labor, through the aid of improvements in the direction of universal education.

"Prior to Europe's 15th century, in all human existence, in every culture, in every part of the world, more than 95 percent of the population of each nationality subsisted in a relatively brutalized condition comparable to serfdom, slavery, or worse."

I have stated this often, but clarity of argument demands that it must be restated for the purposes of this present discussion: Prior to Europe's 15th century, in all human existence, in every culture, in every part of the world, more than 95 percent of the population of each nationality subsisted in a relatively brutalized condition comparable to serfdom, slavery, or worse. It was the impact of the Golden Renaissance, as reflected in the emergence of the modern sovereign nation-state, beginning with Louis XI's France, which began to raise the status of the overwhelming majority of mankind to hopeful expectation of a condition of life fit for a human being.

There was progress before that time. In history, as typified by the best of the classical Greek civilization of Solon's reforms and Plato's Academy, there have been islands of great cultural and scientific beauty, but, until modern times, they were but islands floating in a sea of brutalization of the great majority of mankind.

That mode of education, best described as "Socratic," which fosters the student's reliving the experience of original acts of axiomatic-revolutionary, and other important discovery, typifies the true transmission of the best cultural heritage of all mankind to the present generation, and beyond. That is not mere "textbook education," but rather the invoking of the use and development of the innate creative-mental potential of the student: thus developing in the student the power to radiate, as well as assimilate, old and new such qualities of discoveries in science, technology, and fine arts. That quality of education expresses the not-entropic impulse, which the developed individual personality supplies to the society. It is the power to assimilate those ideas, within the population at large, which defines the upper boundary for the potential rate of growth of the society, in demographic and population-density characteristics.

"The reductionist-deductive is a state of mind, a state which is superseded by creative (Socratic) thinking in that same mind. The first corresponds to an arithmetic or merely algebraic (for example, linear) mode of argument; the opposing second state of mind corresponds to the mental act of reliving valid original discoveries, or generating ones which are new, at least new to the thinking individual who relives them."

Before turning to the second type of constraint to be considered, a closing observation must be made upon what is fairly identified as the "subjectivity" of human knowledge.

To develop a model of reference for creativity (that is, not-entropic human behavior), we have presented two images. The first is the image of the formal (deductive/inductive) theorem-lattice, premised upon an implicitly underlying, fixed set of axiomatic assumptions. The second, is an ordered array of a succession of such theorem-lattices, to represent scientific and analogous advances in combined demographic and population-density through economic growth. This, it has been indicated, is not merely an attempt at a "curve-fitting," operations-research modelling of the case; the axiomatic-revolutionary discontinuities so identified, in the second image, correspond, as marks, to the actual events through which progress is generated.

The two images are accurate abstractions of the Aristotelian, or reductionist-deductive, and Socratic method of argument, respectively. The reductionist-deductive is a state of mind, a state which is superseded by creative (Socratic) thinking in that same mind. The first corresponds to an arithmetic or merely algebraic (for example, linear) mode of argument; the opposing, second state of mind corresponds to the mental act of reliving

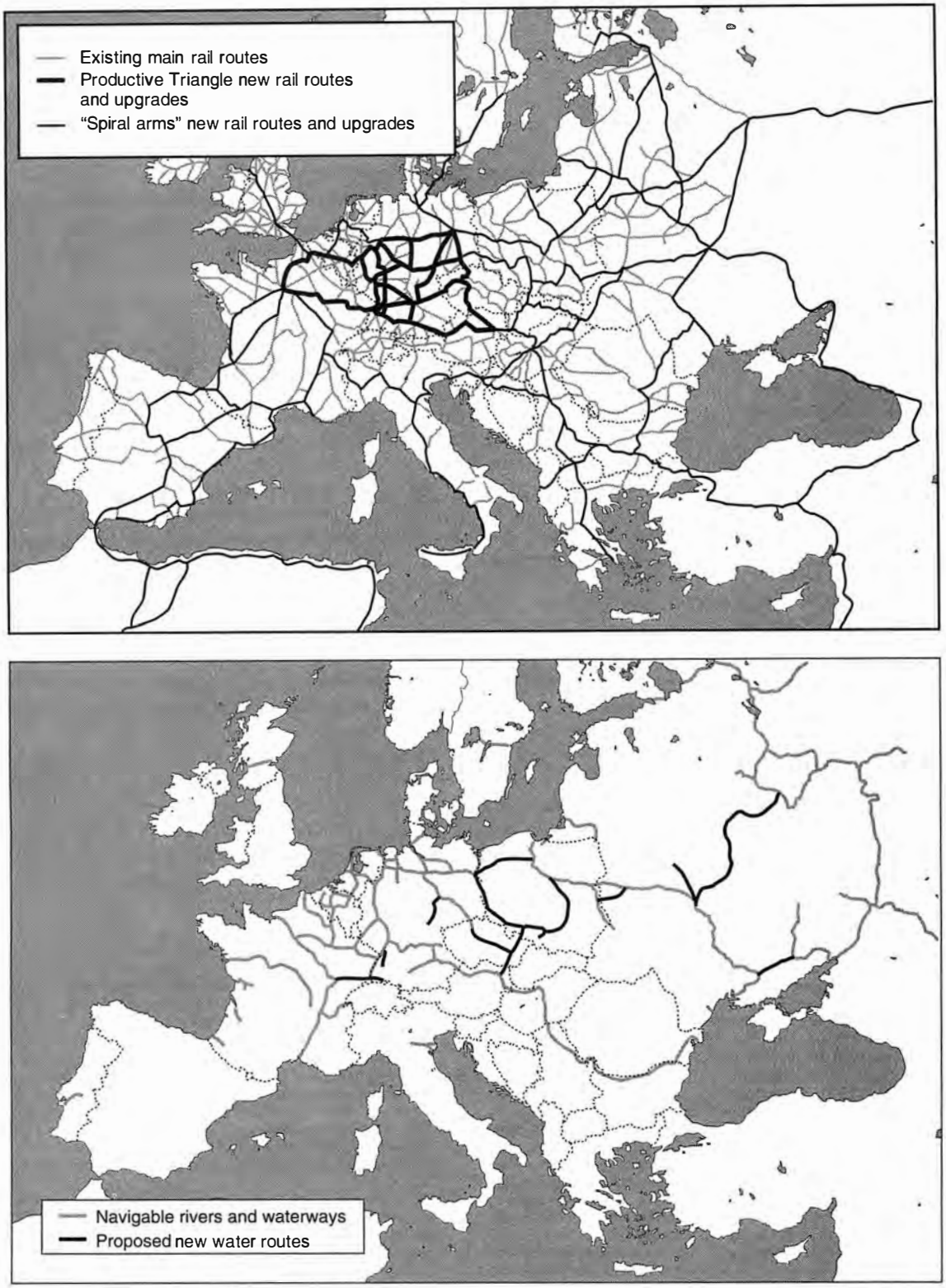

Figure 3
THE PRODUCTIVE TRIANGLE: PARIS-BERLIN-VIENNA
The Productive Triangle, the area bounded by Paris, Vienna, and Berlin, is the most highly developed area in the world in terms of population density, industry, and rail and inland waterway transport.

valid original discoveries, or generating ones which are new, at least new to the thinking individual who relives them. The inability to comprehend this distinction, is the mark of the reductionist, the empiricist, the Kantian: such as a Norbert Wiener or a John von Neumann.

Science, when viewed in these terms of reference, assumes its proper ontological character, as epistemology. The investigations of natural science, as typified by the referenced case of Eratosthenes' measurement of the meridian, are to be viewed *subjectively,* as a matter of uncovering the secrets of human knowledge, the secrets of the way in which the mind is capable, subjectively, of discriminating, with successively lessened imperfection, between valid and invalid conjectures of the individual's imagination.[27] This is the deeper meaning of a non-infinite physical space-time, a "Riemannian curvature of physical space-time."

The constraint which immediately delimits the realization of that not-entropic impulse supplied by an individual's axiomatic-revolutionary creativity, is the extent and degree of the development of the creative powers of the individual mind, within the population in general. The education of the future citizen of the nation-state, to develop the potential of each to generate and assimilate those ideas corresponding to axiomatic-revolutionary discoveries, defines the upper limit placed upon the not-entropic performance of that population itself.

Man Within the Biosphere

Study the maps and relevant satellite images of the planet. Look first at the most highly developed region of modern European civilization, the Paris-Vienna-Berlin "productive triangle," set within a region of Europe from the Atlantic coast of France to the Oder-Neisse border of Germany.[28] (Figure 3). Look at the system of inland waterways and rail-transport. Trace the transmission of electrical power and petroleum and gas feedstocks. Note the densities of power consumption, by agricultural, industrial, commercial, and residential areas.

Compare those images with some crucial data, all measured in per capita, per household, and unit-area values, for various types of land-use types and areas. Measure inputs in physical goods consumed, including power and water, plus education, science and technology as such, and the health-care essential to the longevity and health of the population. Measure per capita productivity of labor in those same qualities composing the market-baskets of household, infrastructure, industrial, educational science, and health consumption (as "energy of the system").

Measure flows of freight through the economy in tons-kilometers-hours, and tons-kilometers-hours per square kilometer of land-use. Analyze the tons-kilometers-hours in terms of relative cost per ton-mile of water, pipeline, magnetic-levitation transport, rail, highway, and airborne transport.

Next, shift attention to the region to the East of the Oder-Neisse, eastward, to the shores of the Pacific (Figure 4). The spectacle is dismal; the lack of density of power, water-development, and transport, virtually precludes reaching levels of productivity comparable to those traditionally available (prior to the 1964-1972 "post-industrial-utopian" paradigm-shift) in northern continental Europe west of the Oder-Neisse line.

Shift again: into the Middle East, and, then, southward, across the Mediterranean, into Africa beyond the Sahara. Make the same comparison, as for Western Europe with eastern Eurasia. What is the agricultural land-area of sub-Sahara Africa? What is the population-density of this land-area, compared with that of Western Europe? How much population could be sustained, at a European standard of food consumption, were this same land-area in use, to be "healed" with modern land-management technologies and supporting basic economic infrastructure in transport, power-transmission, and water-management?

Those comparisons inspire recognition of the meaning of "relative" within "potential *relative* population-density." To make the comparison a more general one, add another case, the prospect of future "science cities" on Mars. After that relatively extreme case of land-use development has been noted, let us return to make the relevant points.

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27. This point is ably illustrated by the stubbornness with which the hoax of Claudius Ptolemy was upheld, into Europe's 17th century. There are three pivotal facts to be considered, respecting the argument at this point in the above text. First, the knowledge, that the Earth orbitted the Sun, had been rigorously established by no later than the time of Aristarchus, during the third century B.C. Second, internal evidence has shown that Claudius Ptolemy's work was a deliberate hoax, intended to eradicate the influence of pre-established scientific proof of the "solar hypothesis" [See Robert R. Newton, *The Crime of Claudius Ptolemy* (Baltimore: Johns Hopkins University Press, 1977)]. Third, the fraud was constructed on behalf of the factional standpoint of Aristotle, against Plato and the approximately two centuries of work of the Academy of Athens and its colleagues, from Plato, Eudoxus, and Theaetetus, through Archimedes and Eratosthenes.

    We must say, without deprecating the actual contribution of Copernicus, that the myth of the "Copernican Revolution" is just that, a myth. The "solar hypothesis" was affirmed by Cardinal Nicholas of Cusa, the leading 15th century canon of the Christian Church, and Cusa's influence on scientific method is the foundation for the subsequent work of Luca Pacioli, Leonardo da Vinci, and Johannes Kepler, and of Leibniz, et al. later. The upholding of the fraud of Ptolemaic astronomy was never an "honest mistake," but a deliberate hoax, from the highest ranks, down, a part of the continuing efforts of the anti-Renaissance, "reductionist" faction of Pietro Pomponazzi, Gasparo Contarini, et al., to eradicate what they abhorred as the "docta ignorantia" of Cusa, et al.

    The issue is clearer, if one poses to the student of Eratosthenes' measurement of the meridian, the question, "How was it possible that Eratosthenes measured the curvature of the Earth with such credible approximation, 2,200 years before any person saw that curvature directly?" Against the background so defined by that question, the origin and revival of Claudius Ptolemy's fraud, is, as a close friend and collaborator would put the point: the "epicycles" are Aristotelian reductionists' "epiphenomena," directly inherited from Aristotle's *Metaphysics.* The post-Renaissance resurrection of the Ptolemaic hoax was part of the Venetian usurers' campaign to turn back the clock of history, to return mankind to that perpetual dark age of brutalization which prevailed prior to launching of modern science by the 15th century's revolution. The function of Ptolemy's hoax, was to outlaw from science that knowledge which defined the higher authority of Platonic ideas, over the alternative of treating sense-perception as a faithful image of a reductionist's supposed reality.

28. *Das "Productive Dreieck" Paris-Berlin-Wien: Ein europaeisches Wirtschaftswunder als Motor fuer die Weltwirtschaft* (Wiesbaden, Germany: Executive Intelligence Review Nachrichtenagentur GmbH, August 1990).

29. The December 1984 death of a dear and respected friend, Krafft Ehricke, inspired Helga Zepp-LaRouche to organize a June 1985 international conference, in Krafft Ehricke's honor. For his part in that Reston conference, the present writer prepared an address, on the subject of "Ehricke's Contribution to Global and Interplanetary Civilization" [*Colonize Space! Proceedings of the Krafft A. Ehricke Memorial Conference, June 1985* (Washington, D.C.: The Schiller Institute/New York: New Benjamin Franklin House, 1985)]. Out of the discussion during that conference, this writer developed his proposed 40-year Mars-colonization mission policy, published several weeks in advance of the Payne Commission's report on a Mars-colonization proposal. The similarities and differences between this author's and the Payne Commission's 40-year programs are notable for anyone studying modern thinking about space-exploration.

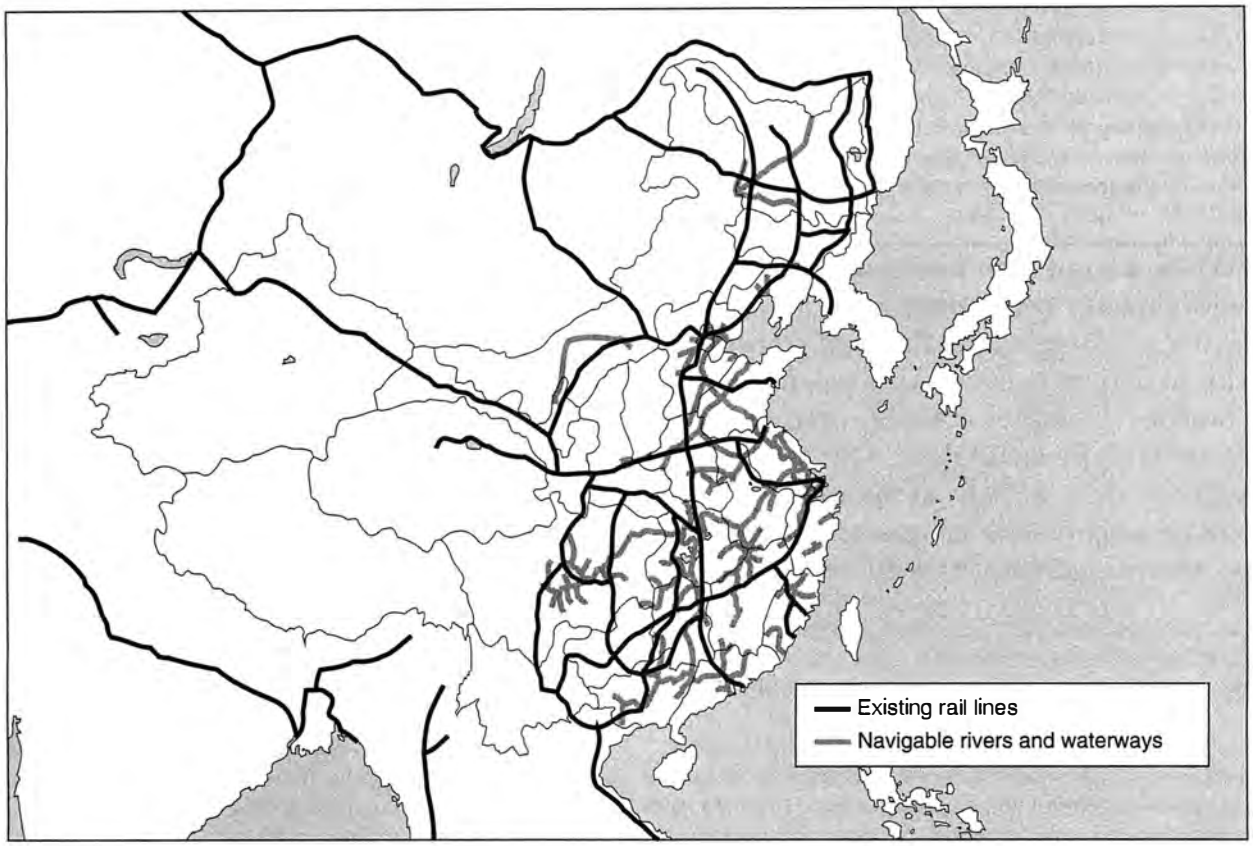


Figure 4
EXISTING RAIL LINES AND NAVIGABLE RIVERS AND WATERWAYS IN CHINA
Without major infrastructure development, China's lack of density of rail and waterway transport as well as power development and other industrial infrastructure virtually precludes the region from reaching even those levels of productivity achieved in postwar Western Europe.

There are two reasons a sane civilization on Earth will have established "science-city" colonies on Mars by the middle of the coming century.

The most visible purpose for establishing such colonies there, over the coming half-century, is that the future welfare of mankind demands the coordinate solution of anomalies on the frontiers of presently known, combined astrophysics, microphysics, and biophysics. Essential parts of this scientific development must be accomplished in a space-environment, as far distant from the Sun as we can reasonably expect to manage such an enterprise with the technologies becoming available during the coming decades.

Two bits of frontier research are most prominently subsumed by that purpose for a long-term Mars-colonization program. The direct target of such a project, is the study of the most stunning astrophysical anomalies in the universe, by exploration of an expanded spectrum of radiation in circumstances as near as possible to a deep-space setting for the observatories and space-laboratories employed. The second chief target is the scientific discovery involved in "getting there." When we put man into space-travel, we are driving our own bodies, and other living processes beyond the limits of science's prior experience; everything we do, in that respect, is either actually, or at least potentially anomalous. One would exaggerate only slightly, at the most, to say of a Mars science-city program: just getting there, is already half the scientific discovery to be made.[29]

The second leading motive for any astronautical-colonization project is that we know, as from the experience of the 1960s' Moon-landing crash-program, that any science-driver program of the scale and intensity a major space-program involves, will pay back to the U.S. economy (for example), within about a decade, about 10 times the cost put into the project itself. A generic term for this sort of motive might be "qualified scientific optimism;" not only the historically validated fact that scientific progress has always increased demonstrably the potential not-entropy of human existence, but that the benefits of large-scale science-driver projects are very impressive in scale, relative to other kinds of productive investments.

Contrary to the Physiocrat delusion, that the profit of enterprise is obtained as the "Bounty of Nature,"[30] man must create

his environment, if society is to rise significantly above very precarious and brutal conditions of life. The challenges of providing a suitable habitat as a "science city" on Mars, and the challenge of transporting human beings back and forth, between Earth-orbit and Mars-orbit, exemplify the point in a relatively extreme degree. It is helpful to compare the challenge of building a science-city in the worst part of the Sahara, with that of putting a "science city" on Mars.

"When we put man into space-travel, we are driving our own bodies, and other living processes beyond the limits of science's prior experience; everything we do, in that respect, is either actually, or at least potentially anomalous. One would exaggerate only slightly, at the most, to say of a Mars science-city program: just getting there, is already half the scientific discovery to be made."

The compared sketches so indicated, illustrate the urgency, that our discussion might avoid the customary fallacy of composition which typically dominates discussions by "ecologists" on the subjects of economy and "the environment." To avoid "ivory-tower" fallacies of composition, and to make the identification of the issues a more manageable one, it is important to divide the discussion of these matters into two stages. First, consider the problem of developing the environment as a matter of physical economy, more narrowly defined. After that, address the broader issue: the impact of economically motivated development of the economy upon the relative viability of the biosphere as a whole. To organize the relationship between those two concluding topics of our argument here, we supply a prefatory remark on the relationship between mankind and the biosphere.

"Is the biosphere as a whole, including man, a process which increases its 'energy of the system' per square kilometer of the Earth's solid-surface-area, without decreasing the ratio of 'free energy' to that 'energy of the system?' This is the question which Arrow et al. ought to have posed to themselves; they did not."

Mankind is part of the biosphere. Restate the same point in thermodynamical terms. To assess the thermodynamics of the biosphere, all human existence and activities must be included as a measure of the level of development of the biosphere.

By "biosphere" we mean, in the relatively narrowest sense, a shell composed of those portions at, below, and above the solid surface of the planet, which are inhabitated by living processes. In a broader sense, in contemplating the very existence of our planet's atmosphere and oceans, we recognize that often what might otherwise be identified even as the inorganic processes of the planet, may owe their existence to the action of self-development of living processes during billions of years. Between those extremes, we strike a balance, and call that "the biosphere." Man is part of that biosphere.

Measure the thermodynamics of that biosphere in terms of power-throughput, *including all of the activities of mankind.* Does man's existence increase, or decrease that throughput? Is the biosphere as a whole, including man, a process which increases its "energy of the system" per square kilometer of the Earth's solid-surface-area, without decreasing the ratio of "free energy" to that "energy of the system?" This is the question which Arrow et al. ought to have posed to themselves; they did not. That is the standpoint from which we should integrate the indicated two successive phases of the immediate inquiry.

In physical-economy, were the demographic characteristics of the population not to deteriorate, the increase of the size and density of the population is a prime source for increase of the productive powers of labor.

Respecting population-density, lowering the average distance among the points of activity, of production and consumption, addresses one of the most conspicuous variables in comparing the net productivities of nations operating at the same general level of productive and related technologies. Shorter lines of transport and communication, mean less cost for transport and communication per capita, for example: a resulting lower physical cost per capita, per household, and per square kilometer for virtually everything produced. An increase of mean distance means an increase of the cost of every variety of physical infrastructure required by an economy. In physical economy, every saving of this type in cost, represents productive capital resources which may be added to the forces of production itself.

Since the relative physical-economic efficiency of many kinds of operating units within economies is strongly affected by "economic lot-size" considerations, the absolute increase of population, means a relatively more economical way of increasing the social division of labor in production and related employment. More important, the greater the number of well-developed personalities, the greater the number of impulses, per capita, represented by the radiation of discoveries which have not-entropic impact; therefore, the intensity of not-

30. It is most relevant in any response to the arguments of today's self-styled "ecologists," to recognize that the mind-set axiomatically underlying their views on the relationship between "macro-economic" profit and nature, is nothing other than the Physiocrat dogma of Dr. François Quesnay. Thus, it was indispensable, in addressing the article of Arrow et al., that we note the hereditary basis for that article's viewpoint in both the interdependent dogmas of "information theory" and "systems analysis," and the common origins of "systems analysis" and "Malthusianism," in the 18th century salons of Venice's Abbot Antonio Conti. Quesnay was a creature of Conti's salons in France; the axiomatics of the argument posed by Arrow et al. are nothing but the axiomatics of Quesnay's Physiocrat dogma.

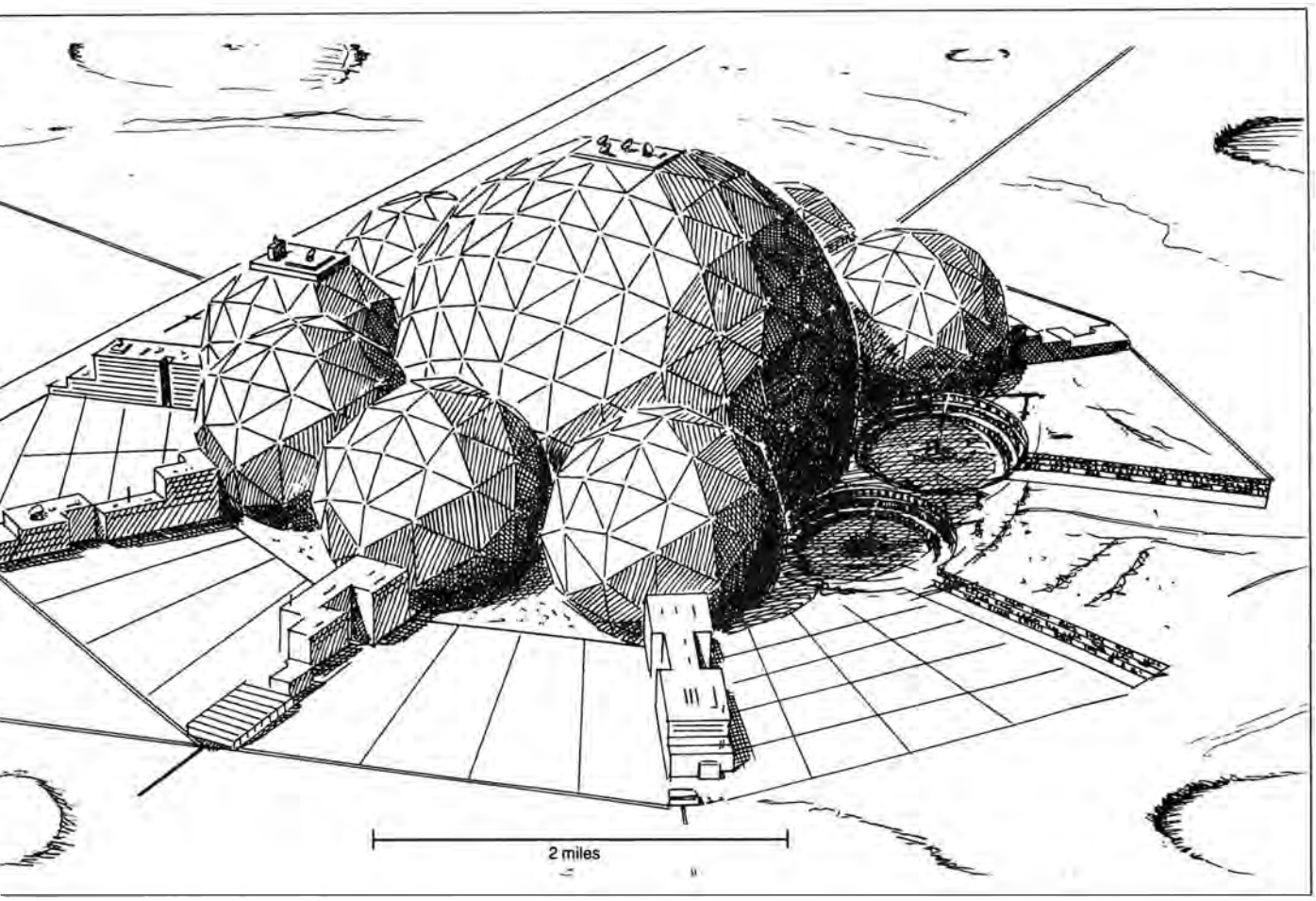


Illustration by Christopher Sloan

"Science city" colonies on Mars in the next half-century will be the laboratory for solving the anomalies of today's frontier areas of astrophysics, microphysics, and biophysics.

entropic impulse per capita is increased relatively in this way.

As a consequence of considerations such as these just cited, the most effective way in which one would approach the development of today's post-Soviet northern Eurasia, would be to make the vastness of this (relatively) thinly populated region economical, by concentrating economic-development within very long development corridors of a modal effective width of about 50 kilometers on either side of a dominating central transport artery of transportation. This central artery would represent one or a combination of the following: an inland waterway, a magnetic-levitation mass-transport system, or a modern high-speed rail corridor. That same central artery would be a pathway for logistical support of closely related, centralized power and pipeline transport. This would be supported by local mass-transport, highways, and other locally adapted distribution modes, forming a system of rib-like spines reaching about 50 kilometers in either direction, away from the central artery.

To sum up that point: Rather than attempting to build up the industrial and related potential of the land-area "on the average," one would concentrate development in high-density development corridors. The economic conquest of the entire territory to be developed, progresses piecemeal, as the territory is digested into the alimentary tract of an increasing number of such high-gain development corridors. Thus, the world should address the challenge of Asia, Africa, South America, and Australia.

The rise of the level of productivity per capita, is conditional upon increased rates of consumption of power, and of such other resources as usable water. One of the ways we manage water, is by moving it from where it is in excess, to where it is needed. Without increasing the amount of water entering a region, we increase the effective water supply by slowing the rate at which fresh water returns to the ocean, not only by canals, dams, and so forth, but by planting cover-crops on reserve land, building up woodlands and forests, and so on. If those means are not sufficient, we lay stress upon reprocessing of waste and related qualities of water. If that were not sufficient, it is cheaper to manufacture water, by large-scale desalination, than to want it.

We improve the climate of the planet, by moderating the weather. The more agricultural and woodland biomass produced per square kilometer, the better. The more desert turned into fertile productive land-area, the better.

We cannot measure the ecosystem—as some prefer to identify it these days—simply in tons, or in calories of throughput,

or in number of species and varieties present. The higher forms of life must dominate, and the lower forms be configured in the degree needed to support the higher ones. So, insecticides are indispensable tools of ecological management, to maintain the level of "the environment." It is the "not-entropy" of the biosphere as a whole (man and his activities included) which must be optimized.

"The difference between the newly founded U.S. Federal Republic of the first, 1790 national census, and the land of those unfortunates left behind in Britain, was that the Americans had more than twice the literacy of the poor sods left behind, and twice the productivity and twice the income."

This illustrates the significance of the "hard" forms of basic economic infrastructure. It was the feudal and financier parasites in Europe, who fostered the Physiocratic delusion, that the colonists in America were but harvesting the Bounty of Nature. The colonists knew the truth. Leave the myth of the "Frontier" to a "Miniver Cheevy" such as "Teddy" Roosevelt, or his favored Frederick Jackson Turner; the bounty of America was no gift of evil Gaia, but the laborious transformation of the relatively barren and unproductive wilderness into developed productive, rural and urban land-areas. The difference between the newly founded U.S. Federal Republic of the first, 1790 national census, and the land of those unfortunates left behind in Britain, was that the Americans had more than twice the literacy of the poor sods left behind, and twice the productivity and twice the income.

The principled significance of public investment in education, science and technology as such, and in support of universal health-care delivery, ought to be obvious. Education, and science and technology, are directly means indispensable for promoting the not-entropic impulses within the society. Health care is essential as it bears upon the health and productivity of the present and future labor-force.

In the process of production, nature and man are in no way inherently adversaries. Rather, the improvement of agricultural and reserve land, plus the development of basic economic infrastructure, are, combined, the principal means by which "free energy" from production is invested to the cumulative effect of increasing the density of the "energy of the system," while maintaining or even enhancing the ratio of "free energy" to "energy of the system." Nature is an integral part of economy, and man is an integral part of the biosphere.

This brings us to the second, concluding point.

Implicitly, at the least, Arrow et al. have forgotten, or simply ignored the historical-economic connotations of such commonplace phrases as "the improvement of land," and "Make the desert bloom!"[31] The dynastic cycles of Mesopotamia, from the fall of the pre-Semitic Sumer of the "black-headed people," through the collapse of the Baghdad Caliphate, are a paradigmatic case for any student of archeological physical economy. The fall of each of the dynastic systems in that region, during that interval, is characterized by the role of tax-farming-related usury in destroying the delicate balance of the system of irrigation, through destroying the "bow-tenure"-based military-economic social structure upon which both the economy and the political stability of the society rested.

The case of the dynastic cycles of Mesopotamia, during a span of approximately four millennia, shows that civilization in this region, as in Egypt, took into account the need to effect a "not-entropic" development of the local portion of the biosphere, through the systematic investment of "free energy" into the accumulation of greater intensities of "energy of the system." With the rise of usurious tax-farming, that stored-up "free energy" in the existing "energy of the system" was looted to enrich the financier interest of that time; the increasing power of the financial class, and the corruption of the political institutions by the practice of usury, was the self-feeding process which set into motion the collapse-phase of the dynastic cycle.

Rosa Luxemburg, whose devastating refutation of Lenin's *Imperialism*[32] typifies her stature as the most astute of the social-democracy's Marxist economists, identified this kind of phenomenon by her refined notion of "primitive accumulation," the monetizing, through plunder, of destroyed volumes of wealth stored-up in nature, or in preceding times' capital contributions to economic development of the productive powers of a population and its "environment." One of the Bolshevik admirers of her professional accomplishments, the economist E. Preobrazhensky, recognized this type of "primitive accumulation" in the Soviet economic system.[33]

If the "environmentalists" were to limit their complaints to the depredations of usury, and related modes of "primitive accumulation," no one could argue reasonably, that they were not contributing a service to man and nature. The trouble is, they have resurrected the ancient madness which governed the Phrygian Cybelline cult of Dionysos. That cult, a synonym for the cults of Shakti-Siva, Ishtar, Isis-Osiris, and Gaia-Python, recruited youth from the leading families of the cities, to assemble them into terrorist youth-movements of brainwashed, anti-science, anti-technology assassins, deployed to kill their own parents. Like "the second generation" of the so-called Baader-Meinhof gang, whose members had been recruited significantly from the Heidelberg (mental) Patients' Collective, the assassins of the cult of Dionysos adopted the cause of destroying modern society, modern science, and modern technology, to turn the world into the direction of a less populous, lunatic sort of bucolic utopia.

The reader would not imagine my aging generation's Kenneth Arrow joining the ranks of such a group of young zombie-killers; but, Arrow contributes to the ideology of such eco-terrorists in the obvious way, by neglecting to calculate the difference between macroeconomic "profit" ("free energy") from development in a not-entropic mode, and a usurious policy of looting the population, productive capital, basic economic infrastructure, and nature itself. The distance from gown to bomb, from such academic negligence, to some Earth First! ecoterrorist's murderous actions, is no greater than the distance between the bombs which Bakunin-accomplice Richard Wagner threw in Lord Palmerston's 1848-1849 revolutions, and the artistic bombs which the same Richard Wagner threw, later, on the musical-theatrical stage.

The questions are these. First, is the development of the

economy itself not-entropic, as we have defined not-entropic here? Second, treating man and his activities as part of the power-throughput of the biosphere, is the impact upon the biosphere of not-entropic modes of economic development (as distinct from the primitive accumulation of usurious modes) also not-entropic?

Is it not then the case, that the radiation of not-entropic impulses from the developed, innate creative powers of the individual human mind, is not only uniquely the source of true profit in economic processes, but also a source of not-entropy radiated into nature in general?

"The 'most economical' assumption, is that the universe is designed in such a manner, that professors of biology and inorganic physics, can both exist as an organic part of that universe. That evidence is already clear beyond reasonable objection. If the 'environmentalists' wish to redeem themselves, they should be guided by the implications of that clear fact in redoing their inquiry."

From a dusk-filled, different corner of the room, comes a protesting voice. The owner of that voice is irate, that we dare to propose that the creative powers of the individual human mind could radiate not-entropic impulses efficiently into the inorganic domain, perhaps the domain of subnuclear microphysics.

The model for the appropriate sort of shorter reply to that objection, was supplied by Bernhard Riemann's ridiculing of Isaac Newton's *hypotheses non fingo*.[34] In the case of the objection from the dusky corner, as in Newton's illiterate use of the term "hypothesis," the introduction of the rule of "Ockham's Razor" is itself an extravagant assumption. To assume, barring contrary evidence, that something is true, is the most contemptibly banal of all sophistries. Today's "Ockhamite" sophist assumes, that since the reductionist assumptions respecting the onta of the microphysical domain are "more economical" than an arguably hylozoic one, that the reductionist position must be asserted, pending explicit evidence to the contrary. On the premise of that sophistry, taken as axiomatic, he then dispenses with precisely that evidence which does disprove his case, by asserting, that all living processes must be traced ultimately, axiomatically, to his present, reductionist assumptions respecting the ontology of the ultimately small. Pure sophistry!

Not only does mankind, a living process, exist in the universe, but, it is only through the intellectual powers of mankind that we possess any knowledge of that universe. What we may classify as knowledge, depends upon the practical effect of acting upon that knowledge, as measured in the impact upon the condition of human existence, even the possibility of continued human existence itself. Thus, does all knowledge pertain to man's willful power to impose mankind's improved status within the universe, to affect the state of the universe in this way.

There are relevant experimental inquiries to be made, to this effect. Among those experimental inquiries is the study of the anomalous fact, that the same chemical compositions which may be, in one moment, living processes, may be, in the next, non-living organic processes. Related anomalies are prompted to our attention once we contemplate that one. For example, is there, perhaps, some optical-biophysical difference in the state of a molecule within a living process, and the equivalent molecule not part of a living process? The answers must wait for the relevant experimental inquiries, but the evidence which prompts such inquiries is already clear.

The "most economical" assumption, is that the universe is designed in such a manner, that professors of biology and inorganic physics, can both exist as an organic part of that universe. That evidence is already clear beyond reasonable objection. If the "environmentalists" wish to redeem themselves, they should be guided by the implications of that clear fact in redoing their inquiry.

Economist Lyndon H. LaRouche, Jr., is a member of the scientific advisory board of 21st Century.

31. During this century, many adorned with the highest grades of professional reputations in such fields as the history of science, archeology, and so on, have participated in propagating fairy-story science respecting the supposed "birth of civilization" in Mesopotamia. As a by-product of the 1582 victory of Paolo Sarpi's faction within Venice's financier nobility, the northern portions of Europe consigned to the forces of the Reformation were adopted as the place in which to build an Anglo-Dutch clone of Venice, to become worldwide, the kind of financier and maritime power which Venice had come to represent for the Mediterranean region.

    Out of this, there arose among British anti-Semites a "Low Church" mythology, to the effect that the Anglo-Dutch, the Germans, and the Scandinavians were bearers of the Convenant, as representatives of the Ten Lost Tribes of Israel.

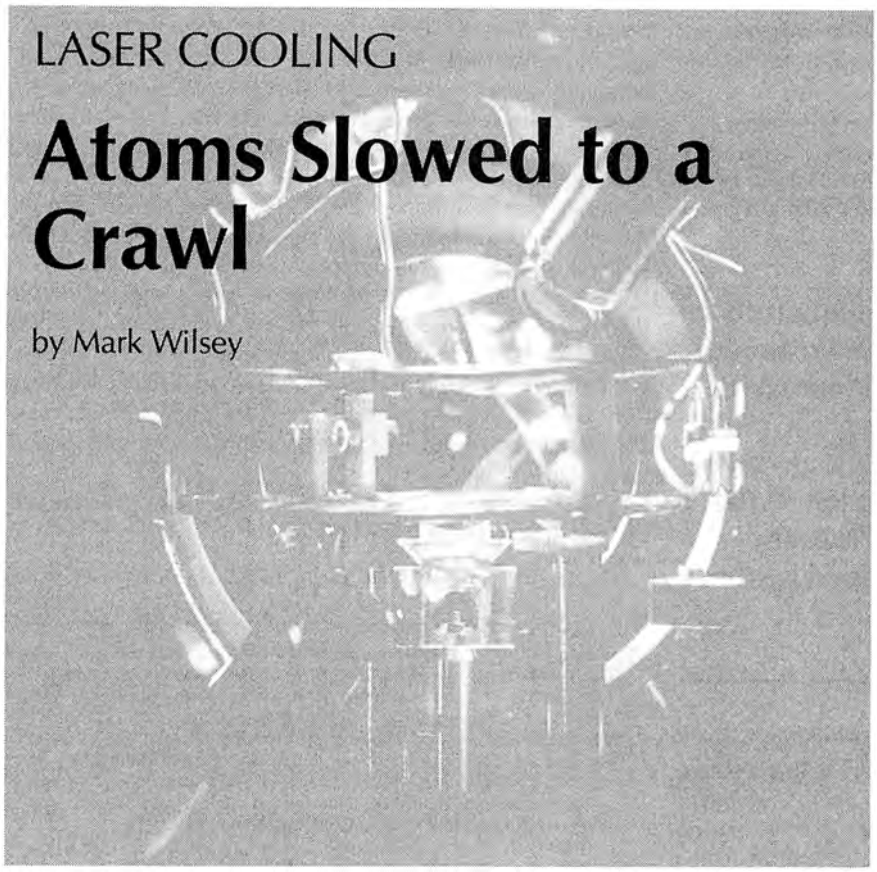
    In service of that myth, we acquired such more recent products as the British role in producing Adolf Hitler's Nazis, and the comi-tragic spectacle, or, if you prefer, farce of 19th century British Imperial "Biblical Archeology." Witness, in ritual references to the history of science by notable scientists, the contorted efforts at "political correctness," contrary to all fact, to affirm the British myth, that "history and science" began in Mesopotamia. (This matter was the subject of a book-length study, which the present author produced in 1982.)

    Out of this sorry spectacle came the "hydraulic culture" myth-making of Kart Wittvogel, for example: another version of the British mythical history of culture, from food-gathering, to agriculture, to riparian civilizations, to maritime cultures. Simple calculations, corroborated by crucial archeological evidence, show that the development of modern civilization could have come only by a different route-sequence: fishing, to maritime culture, to production of the germs of agriculture as a by-product of maritime culture, to riparian cultures developed in the estuaries of key rivers, and so on. Had any of the relevant professors of anthropology troubled to make a few elementary calculations, the hoax of British archeology would have been quickly apparent to them. Arrow et al. exhibit the same folly respecting the calculable nature of the historically known role of land improvements in the development of physical economies.
32. Rosa Luxemburg, *The Accumulation of Capital*, Agnes Schwarzchild, trans. (New York: Monthly Review Press, 1964).
33. It was that factor of long-term "primitive accumulation," inherent in the Soviet System under Stalin, Khrushchev, Brezhnev, et al., which caused the 1989-1991 collapse of the Soviet system; it is the older form of "primitive accumulation," instituted by the governments of Margaret Thatcher and George Bush, conducted under the rubric of "reform," which has done more, since 1991, than all the earlier regimes in that region during the preceding five centuries.
34. *Riemanns Mathematische Werke*, p. 525: "Die Unterscheidung, welche Newton zwischen Bewegungsgesetzen oder Axiomen und Hypothesen macht, scheint mir nicht haltbar. Das Traegheitsgesetz is die Hypothese 'Wenn ein materieller Punkt allein in der Welt vorhanden waere und sich im Raum mit einer bestimmten Geschwindigkeit bewegte, so wuerde er diese Geschwindigkeit bestaendig behalten.' "

LASER COOLING

Atoms Slowed to a Crawl

by Mark Wilsey



NIST

◀*Physicist Kris Helmerson (face partially obscured) observes a tiny glowing cloud of sodium atoms caught by six intersecting laser beams—a technique that can produce the coldest temperatures in the universe.*

Elementary physics tells us that the temperature of an object is related to the motion of its atoms. The faster the atoms move, the more thermal energy they have and the hotter they are. In theory, therefore, the coldest temperature would be that in which all atomic motion has ceased. Physicists call this absolute zero, or 0 kelvin (−273.15°C). Although in practice this point will never be reached, experimenters have come to within less than a millionth of a degree of absolute zero.

Scientists are keenly interested in studying the behavior and nature of atoms at ultra-low temperatures. In addition to the scientific and technical challenge of approaching absolute zero, new technologies are expected to come out of this research that may improve by orders of magnitude the measurement of time or even allow us build microelectronic circuits atom by atom.

An atom at room temperature clips along at about 200 meters per second. (Although it moves fast, it doesn't actually travel that far because it is constantly changing directions, bumping into other atoms or bonding to other atoms.) An atom cooled to near 0 K, however, is slowed to less than 1 centimeter per second.

Over the past several years, many techniques have been developed to cool, trap, and manipulate particles at ultra-low temperatures. Ions, because of their electrical charge, have been particularly amenable to being corralled in magnetic and electrical fields. Neutral atoms, which have no charge, are a little more difficult to control. Here, laser cooling, using laser beams to slow and snare atoms, has been very successful. Many aspects of this technique were developed at NIST, the National Institute of Standards and Technology, in the 1980s.

At the spring 1995 meeting of the American Physical Society in Washington, D.C., Steven Rolston of the atomic physics division at NIST made a presentation on laser cooling as part of a symposium featuring physics research at NIST.

Laser cooling is possible, Rolston explained, because photons, packets of light energy, carry momentum and can be directed in such a way as to exert a force on an atom. As an atom absorbs a photon, the transfer of momentum between them can cause the atom to slow down.

However, the atom emits another photon for each photon it absorbs. Because the direction of the emitted photon is random, the "recoil" force is canceled out over time, while the momentum of the oncoming photons being absorbed exerts a net force on the atom. This is called the scattering force.

Optical Molasses

The simplest experimental configuration consists of two opposing lasers. For any atom of a given element there is a particular wavelength of light that it will readily absorb—its natural resonance frequency. The frequency of the laser light is selected to be slightly lower than this optimal value for the atoms being cooled. To an atom moving in the direction of a laser, the light will appear to be at a higher frequency (because of the Doppler effect)[1] and will be absorbed by the atom.

The light from the opposite direction will appear to be even lower in frequency and is less likely to be absorbed by the atom. When the atom changes direction and moves toward the second laser, the process is reversed, and the light from the first laser is ignored while the light from the second is absorbed. By this process, the motion of atoms in both directions—or along one axis—is slowed down, thereby cooling them.

The physical effect on the motion of the atoms within these laser beams is analogous to viscous dampening. One example of such dampening would be a simple shock absorber in which the motion of a piston in a cylinder is impeded by a fluid. In the case of laser cooling, it is as if the atoms had been thrown into a highly viscous medium—a condition

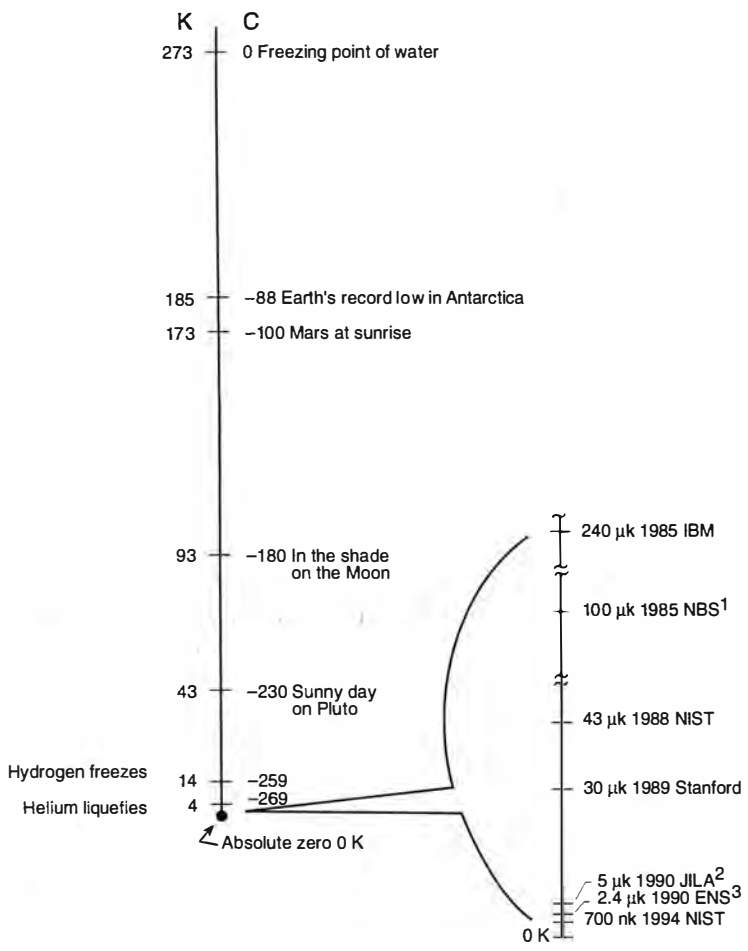


Figure 1
HOW COLD CAN ATOMS GET?
The figure shows some natural phenomena in terms of the Kelvin and Celsius temperature scales, as well as laboratory milestones reached in laser cooling.

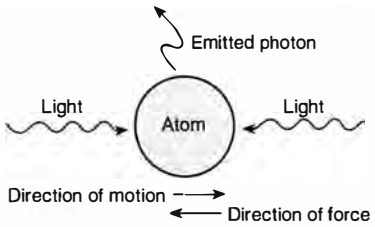


Figure 2
LASER COOLING AN ATOM
When an atom absorbs a photon (in this case, photons directed at the atom by a laser), the atom slows down. At the same time, the atom will emit another photon in a random direction. Over time, the "recoil" forces of the randomly emitted photons cancel out, leaving a net force (called the scattering force) exerted on the atom by the momentum of the incoming photons.

that has been dubbed optical molasses.

Rolston explains that such techniques may not enable one to reach a velocity of zero because there will always be some heating caused by the presence of light and fluctuations in the system. However, it is possible to calculate the temperature one may attain by this means. For sodium atoms, Rolston says, the NIST team expected a temperature of about 240 microkelvin (μK), or 240 millionths of 1 degree. Experiments done in 1988, however, found the temperature to be more than an order of magnitude cooler than predicted. Clearly there was some other cooling mechanism at work.

In addition to the scattering force from the photons, there is what Rolston calls the dipole force, which is created by the electric field associated with the light. This electric field oscillates at the optical frequency and causes a slight displacement of the negative electrons from the positive nucleus, such that the atom behaves like a dipole. (A dipole is simply an object with two poles, either electrical or magnetic.) In this case, the induced "dipole" condition of the atom then interacts with the electric field that created it, producing a force on the atom.

As the atom moves, it picks up energy from the field, which also impedes its motion. This energy is then emitted by the atom. In this way, some of the kinetic energy of the atom is dissipated as radiant energy and cools the atom.

Optical Lattices

To hold atoms in place and cool them in three dimensions requires more than just a pair of opposing laser beams. A stable interference pattern produced by multiple laser beams that is capable of cooling and trapping atoms is called an optical lattice.

An optical lattice is analogous to a crystal lattice in that it is a regular three-dimensional array—in this case, "optical potential wells" into which a cold atom may fall. At such low temperatures, the atom does not have enough energy to overcome the potential, like BBs falling into the holes of a child's toy. Unlike a crystal whose lattice constant, the distance over which its pattern repeats, is only a few angstroms, the optical lattice has a constant on the order of 1,000 angstroms. (1 angstrom equals 1×10^{-10} m.)

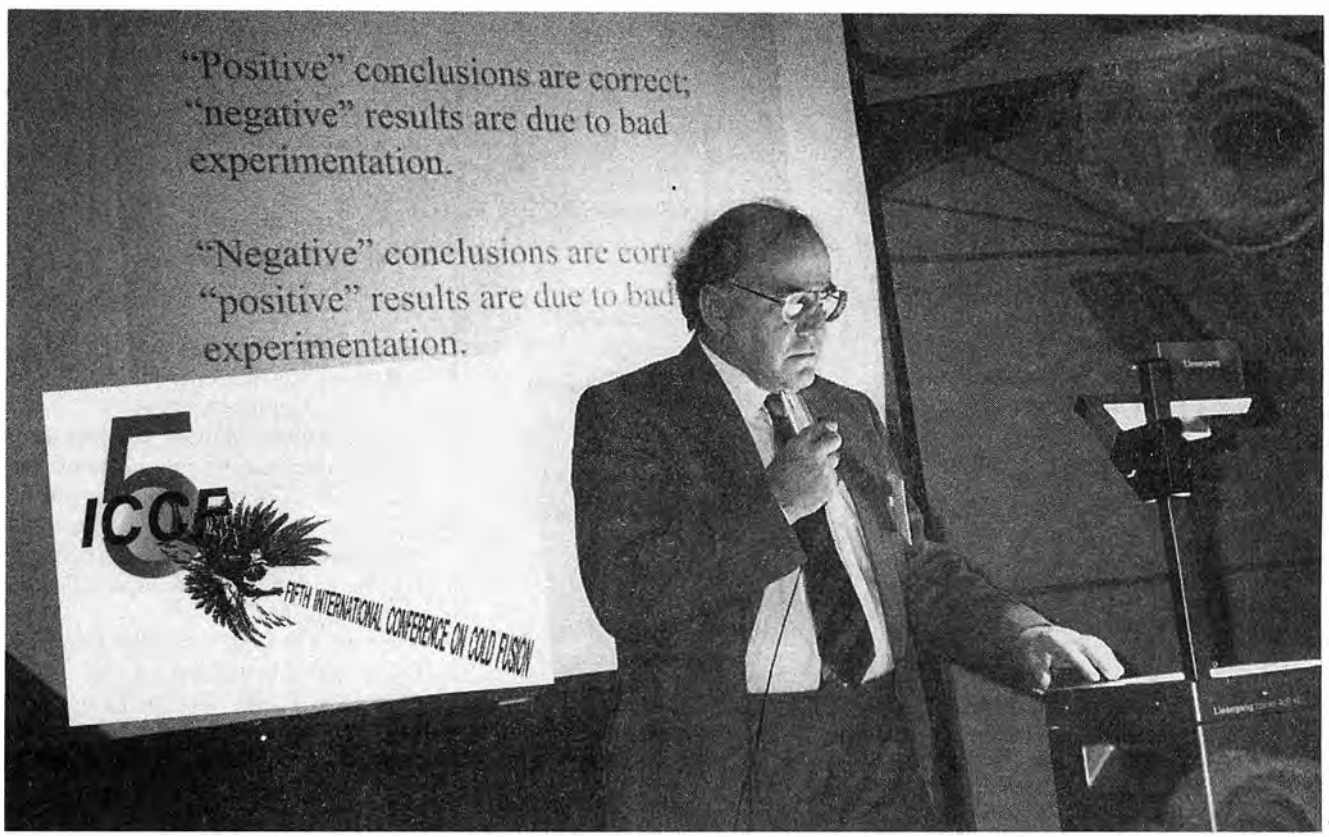
One of the difficulties in laser cooling experiments, according to Rolston, is to isolate the lasers from vibrations. For a more stable optical lattice, NIST uses a four-laser configuration. Two laser beams cross each other at 90 degrees in the horizontal plane. The other two laser beams, also at 90 degrees, intersect the first two from the opposite direction in

Continued on page 67

THE 5TH INTERNATIONAL COLD FUSION CONFERENCE

Slow, Steady Progress and Some Fast Talk

by Carol White



Carol White

Martin Fleischmann addresses the Fifth International Conference on Cold Fusion. The logo of the conference depicts Icarus, the Greek mythological figure.

The Fifth International Cold Fusion Conference (ICCF5) was held in Monte Carlo, Monaco, from April 9 to 13, with 208 participants from Belarus, China, France, Germany, Hong Kong, India, Italy, Japan, the Netherlands, Republic of Korea, Russia, Spain, Switzerland, the United Kingdom, and the United States. It was hosted by electrochemists Martin Fleischmann and Stanley Pons. Although there had been rumors before the conference that Fleischmann and Pons would have distillation cells on display either at the conference or in their nearby laboratory, this was not to be; however, there was a working demonstration of the first cold fusion cell to be granted a U.S. patent, a light water cell designed by veteran inventor James Patterson.

It was in many ways a disappointing conference. Cold fusion has proven to be a far more difficult research area than we might have thought six years ago. Although progress has been made in understanding the experiment, it has not been as rapid as one might have hoped.

ICCF5 might best be described as two conferences, held simultaneously and in the same location and even attended by the same people. But otherwise they had little in common, although both were ostensibly about cold fusion.

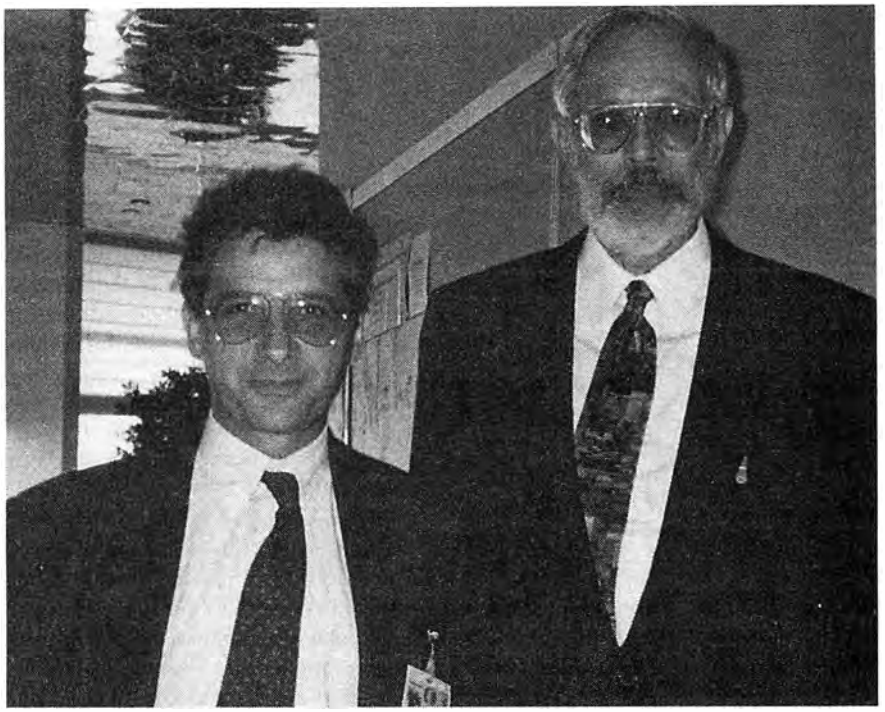
One of the conferences was a rather sober affair in which a grouping of primarily Japanese, American, Italian, and Russian scientists held a concentrated discussion over the five days to evaluate the past year's work and coordinate research plans for 1995-1996.

Attendees at what I have chosen to call the other conference were anything

but sober. In their view, much of the discussion about about how to achieve successful results following the Fleischmann-Pons model, or variations on it, was simply beside the point. For them, the main focus in the field should be shifted to development rather than fundamental research. Indeed, they claim, cold fusion is a product which will be marketable in the immediate future.

Both "conferences" occurred in an atmosphere shaped by the unremitting attack to which the fledging scientific field has been subjected, almost from its beginning. Funding, in the United States especially, has virtually dried up in the aversive political climate deliberately fostered by opponents of cold fusion. John Huizenga—who chaired the U.S. Department of Energy blue-ribbon panel convened after the 1989 announcement by Fleischmann and Pons—has continued to intervene wherever he could to urge that research be shut down. As a result, promising experimental programs have been terminated because they could not get funding.

Those scientists in the United States, and to some extent in Europe, who have continued to work on cold fusion have had their careers threatened, and have in some instances also been subjected to abuse. This has tended to reinforce a defensive—even embattled—attitude among those who have continued in the field at a real personal cost. This has led to a certain tendency to overemphasize positive results and downplay failures. Although this is understandable, it is also deplorable. Indeed, it is often through apparent experimental failures that the most progress is made.



Carol White

Edmund Storms (right), retired from Los Alamos National Laboratory, gave the keynote address, emphasizing the broad array of experiments that confirm chemically assisted nuclear reactions. With him is Francesco Celani of the Italian National Institute of Nuclear Physics at Frascati.

Advances in the Field

Over the years since the original announcement of the discovery, repeatability has certainly been the bugaboo. Gradually, some understanding has been gained of the initial conditions necessary for the production of excess heat. One of these is the establishment and maintenance of a high concentration of deuterium in the palladium cathode. Another is the presence of certain additives to the electrolyte, such as silicon and aluminum, which collect on the surface of the palladium and most likely help to slow the recombination of deuterium atoms into molecules when they are outgassed from the palladium. Important also is the achievement of a threshold current density in electrolysis experiments.

At this conference there was serious discussion of the pretreatment of palladium and also of methods of determining criteria by which unusable palladium can be discarded in advance of an experiment.

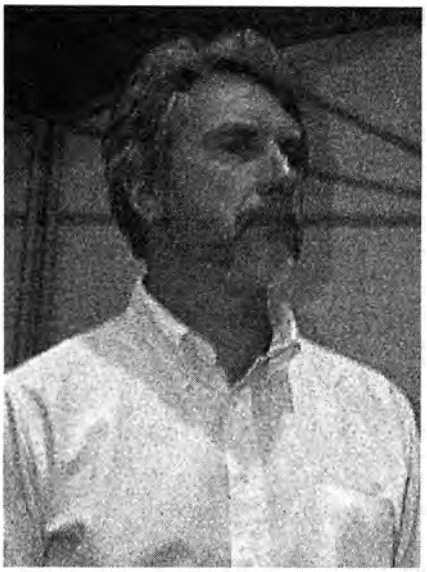
Edmund Storms, who is retired from Los Alamos National Laboratory, gave the keynote address, which emphasized the broad array of experiments that confirm chemically assisted nuclear reactions. He also discussed protocols that he believes can guarantee success in achieving excess heat. (These were reported in the Winter 1994-95 *21st Century,* pp. 60-61.) His review of the field was extremely upbeat, but he nevertheless devoted serious attention to some of the problems associated with improving reproducibility.

There is widespread agreement that an overall ratio of deuterium to palladium atoms (the D/Pd loading ratio) somewhere above 85 percent is desirable in order to produce excess heat in a Fleischmann-Pons experiment. Normally, a palladium lattice will have what is called a face-centered cubic structure; however, at high loadings of hydrogen or deuterium, this structure has been known to change. It is of course possible that an endothermic/exothermic transition can occur, irrespective of whether there is a phase transition, as Steven Crouch-Baker of SRI pointed out in his presentation.

Such a change may affect the possibility of cold fusion occurring in several ways; for example, by changing the proximity of the deuterons to each other. Or it could change the thermodynamics—whether loading hydrogen or deuterium into the lattice causes an energy release (is exothermic) or instead requires an addition of energy (endothermic). Or the change in the palladium lattice structure could affect cold fusion in other ways.

On the other hand, the cold fusion reaction is highly localized, so that the local concentration of deuterium within the lattice is also an important parameter.

The relationship between current density and excess heat production is well established. There is also a correlation between over-voltage and loading. One question yet to be answered is whether there may be a saturation curve for energy input. Is there perhaps also, as Mar-



Carol White

Michael McKubre, leader of the Stanford Research Institute cold fusion research team, told ICCF5: "Progress has indeed been made, but it has been somewhat slow and somewhat unsteady, but certain! Wielding science, we have fought against ignorance, envy, and malignant self-interest. However, if we cannot define our progress in rational and concrete terms, we will have a much more difficulty adversary—apathy."

tin Fleischmann contends, a positive feedback that occurs with a rise in temperature? If this is the case, then it is clearly desirable that the palladium-deuteride be in an endothermic rather than exothermic phase, so that the higher temperature does not immediately cause the palladium to outgas deuterium.

So far, only Storms has tested Fleischmann's hypothesis that there is a correlation between temperature increase and higher excess heat production. In his experiments reported at the Third International Conference on Cold Fusion, Edmund Storms did find indications of such a correlation of increased heat production as the temperature was raised. Unfortunately, he was not able to pursue these experiments for lack of funding.

The subtleties involved in measuring excess heat is one area of difficulty in pinning down the experiments. In most cold fusion experiments the actual amounts of excess power are relatively small, and in some instances—not only at boiling or near boiling temperatures, but also in high-voltage experiments among others—highly transient phenomena are involved.

The Stanford Research Institute (SRI) team led by Michael McKubre has had the most comprehensive and successful experimental program to date, yet his assessment of the state of affairs, while optimistic, was sober. He began his presentation with this assessment: "We have some interesting new results that suggest better reproducibility of conditions for excess heat production." But, he continued, "Not many people here today would have suspected that after six years of study, the field revealed by Fleischmann and Pons would have survived but not thrived."

"Progress has indeed been made," McKubre said, "but it has been somewhat slow and somewhat unsteady, but certain! Wielding science, we have fought against ignorance, envy, and malignant self-interest. However, if we cannot define our progress in rational and concrete terms, we will have a much more difficulty adversary—apathy. It is too late to be vague; we must be precise, we must quantify. I hope to introduce some concepts that will allow us to do that better than we have." Making the attainment of precision much more difficult, and greatly restraining progress, he said, are two very difficult problems: the (apparent) irreproducibility of results and the scarcity of (nuclear) products.

"I will address the first of these and direct attention to the following questions: What conditions do we need to achieve for the reproducible attainment of excess power? What factors prevent us from achieving these necessary starting conditions? What procedures can an experimentalist employ to obtain reproducible results?"

Another Side to the Story

For those whom I have described as attending the "other conference," the mood was one of exuberant vindication. Not only do they believe that "cold fusion" has been proven beyond doubt but, in the main, they are convinced that the phenomena described by Fleischmann and Pons have proven to be only the tip of an alchemical iceberg (see box, page 59).

The important point is not whether substantiation exists for some of the various claims presently being made on behalf of light water fusion and various other, alchemical reactions, and certain mechanical devices that supposedly tap zero-point energy from the vacuum—something which I greatly doubt. These claims would still be largely irrelevant to the pressing task of pinning down the phenomena presently grouped under the rubric of cold fusion, in order to understand what might actually be going on.

To assemble a collection of marvelous reports, or, one might say, reports of marvels, cannot replace a rigorous scientific effort. Furthermore, the uncritical acceptance of just about anything—which characterized some circles at the conference—serves the enemies of cold fusion well in discrediting serious scientific effort in the field. There were even some people at the conference peddling a perpetual motion machine.

It was this grouping—what I have chosen to call the other conference—to which were attached a number of entrepreneurs, or at least would-be entrepreneurs. These people were trying to sell investment in cold fusion—or some more rococo version thereof—on the grounds that the time is near at hand when practicable devices will be marketable, even for home use, as for example hot water heaters.

Unfortunately, this is not a situation unique to cold fusion, although marketing is glaringly premature for cold fusion. The proposition that scientists must hawk their wares in order to gain support for their research is by no means restricted to the cold fusion community. In fact, U.S. national laboratories are demanding precisely that from their staffs. If you wish your project to be funded, then find some industry to whom you can sell a share of your work. Find a salable application of your research, buddy, if you want to stay in science.

Even leading American universities are now pegging the salaries of tenured professors to their ability to bring in grant money. "Publish or perish" used to be the byword for academics if they wished to achieve tenure. Now, not only must they solicit grants to support their research, but their very ability to continue teaching is being pegged to their ability to "market their product."

The Patterson Cell

It will be a great irony indeed, if the only cold fusion patents issued so far in the United States—those granted to James Patterson—turn out to be granted for a device which does not actually pro-

The Entrepreneurs of the 'Other Conference'

Wayne Green is the publisher of *Cold Fusion,* a newsletter that was previously edited in glossy magazine format by Eugene Mallove, now editor of a magazine called *Infinite Energy.* Although they have disagreed publicly on many issues, Mallove would not disagree with some comments on the Monaco conference circulated by Green in a flier intended to generate advertising for his science newsletter. Green wrote:

"A New Technology—A New Market!

"With the proof by Dr. James Patterson that the critics of cold fusion are full of . . . er . . . baloney, a new excitement has been generated for cold fusion research. Patterson's patented cold fusion cell sat there for the four days of the April Monaco cold fusion conference in a tabletop demo, perking away, turning out up to 600 percent excess heat. The cell was carefully checked and its operation confirmed by scientists from 15 countries. . . .

"While there is finally agreeement that cold fusion really does work, research is just beginning. . . . Now, with funding finally beginning to loosen up, how much do these scientists know about your products and services? . . ."

Similar are the claims made in Hal Fox's newsletter, *Fusion Facts.* In a story on the conference in the April issue, Fox wrote of the Patterson cell: "One of the most impressive presentations . . . was given by Dr. Dennis Cravens and supported by a working cold fusion cell set up in the foyer by Clean Energy Technologies, Inc. (CETI) of Dallas, Texas. Attendees at the conference could take their own data, compute the results, and show that a cold fusion cell was operating at 200 to 400 percent excess thermal power. This cold fusion system utilized the patented inventions of James A. Patterson. . . .

"Not only was the working reactor a successful scientific presentation but it was also one of the forerunners of the commercialization of cold fusion. . . .

"We have long touted the concept that the cold fusion developers need to demonstrate cold fusion reactors that are reproducible and that provide thermal power that is at least 300 percent larger than the input power. The stage has now been achieved. . . . Now we have cold fusion thermal power available at about the cost of natural gas thermal power *but without the pollution of the atmosphere".* [emphasis in original].

In the May issue of *Fusion Facts,* Fox develops the theme that this excess energy is obtained from the vacuum: "Because there is an energetic ether, enhanced energy devices are merely *energy transformers.*"

He goes on to say: "The good news is that there are now a few enhanced energy devices that have been developed, commercialized, and are being manufactured and marketed. As is generally true in the advancement of science, we do not, as yet, fully understand how any of these devices work. The theory of their operation has not caught up with established fact. . . .

"At the present time, we have several companies who are manufacturing and marketing enhanced energy devices or systems. At least two other companies are prepared to provide rights to a selection of intellectual property (patents issued or pending) which combined provides a variety of cold fusion and enhanced energy technologies." Fox then mentions another of his newsletters, *New Energy News,* which will be running a commercial column to list companies and their products.

Unfounded Claims

Not only are Fox's claims unfounded, in my opinion, but were they in fact true, the possibilities for exploiting the technology would be-to say the least—severely limited by the unfortunate realities of nuclear politics, not least the presently suppressive role of the U.S. Nuclear Regulatory Commission. In addition, there are real questions of nuclear safety.

Cold fusion is presumably a nuclear reaction, even though there are sometimes no observable nuclear by-products, such as neutron emissions or tritium production. Nevertheless, if cold "fusion" involves any kind of nuclear reaction, then a potentially lethal radioactive emission might be triggered in ways not presently anticipated.

Furthermore, Fleischmann and Pons report a laboratory explosion which occurred in 1986, at a time when they were not present, and there was a fatal accident at SRI in January 1992. Perhaps these were merely chemical accidents due to the catalytic recombination of hydrogen and oxygen; perhaps they were triggered (at least in the case of SRI) by a nuclear generated heat burst, or, perhaps one or both might have been actual nuclear explosions. One can imagine any number of scenarios (such as unexpected power surges) in which dangerous explosions might be triggered.

A better understanding of what is involved in the phenomena associated with cold fusion—so that untoward events can be anticipated and proper controls established—will be necessary before we are ready to consider situating cold fusion devices in homes.

duce excess heat. (His patent has been granted for a light-water cell.) Patterson, along with members of his family, has already formed a company, CETI (Clean Energy Technologies, Inc.), that is intent on marketing his device.

He claims to get a heat excess of up to 600 percent from a light water cell and a 30 percent higher excess using heavy water. The powers involved, however, are on the level of watts, rather than kilowatts, making this a low-grade heat source of dubious commercial value at best. It might however, prove to be an interesting teaching device.

Dennis Cravens, a physics teacher at Vernon Region Junior College in Vernon, Texas, and a member of the ENECO Science Advisory Board, was asked by CETI to evaluate the cell. (ENECO is a company involved with the commercializa-

tion of cold fusion.) He prepared a careful report which concluded that "Nothing discovered during the evaluation of the cell is inconsistent with the production of excess heat. . . . [R]egardless of the cause, the system does give repeatable results at substantial levels. If, as expected, the power levels persist with tighter experimental bounds in the low current levels, then the system should have important practical and commercial applications." His verification was based upon improvements in the original Patterson calorimetry. According to Cravens, problems in temperature measurement made the efficiencies of the original Patterson cell only around 20 to 30 percent.

A Patterson light-water cell was set up each day of the conference in the anteroom of the meeting hall. Attendees were invited to witness temperature readings, from which heat gain could be inferred. Unfortunately the cell had to be moved from the anteroom each day. As a result, when it was tested by two scientists, Haven E. Bergeson and Steven Barrowes from Utah University, they found a half-watt deviation in the calorimetry and inaccurate temperature measurements. Since the demonstration was not occurring in a laboratory, such problems were to be expected. Unfortunately, however, claims have been made implying that the scientists who observed the cell in action at the conference were in a position to validate Patterson's claims. Sheer nonsense.

The Patterson cells (Figure 1) contain microscopic resin beads, which are coated successively with very thin coats of copper chloride, nickel, palladium and finally nickel—about 2 microns each. They are bathed in an electrolyte containing boron, which used tap water and lithium sulphate.

There are 1,200 beads per cell, but they use only 40 milligrams of metal. Platinum plates are used for the anode, and to introduce current to the beads, which serve as cathodes. A nickel coating is put on the outside of the beads to stabilize the palladium, in order to prevent cracking as the beads expand and contract.

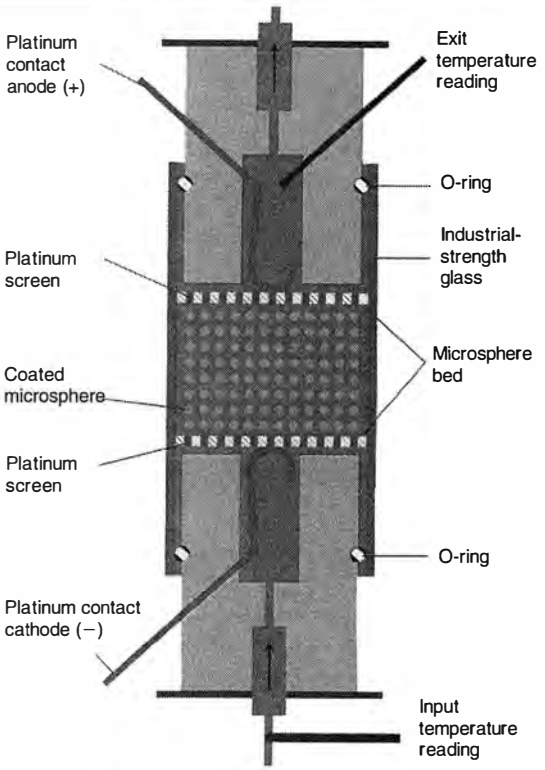
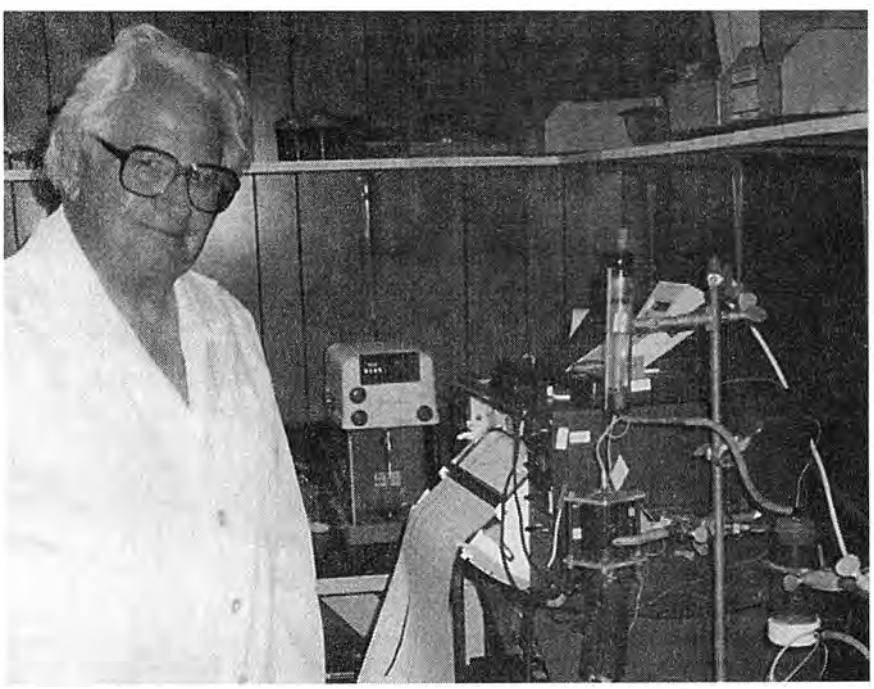


Figure 1
SCHEMATIC OF THE PATTERSON POWER CELL™



Courtesy of James Patterson

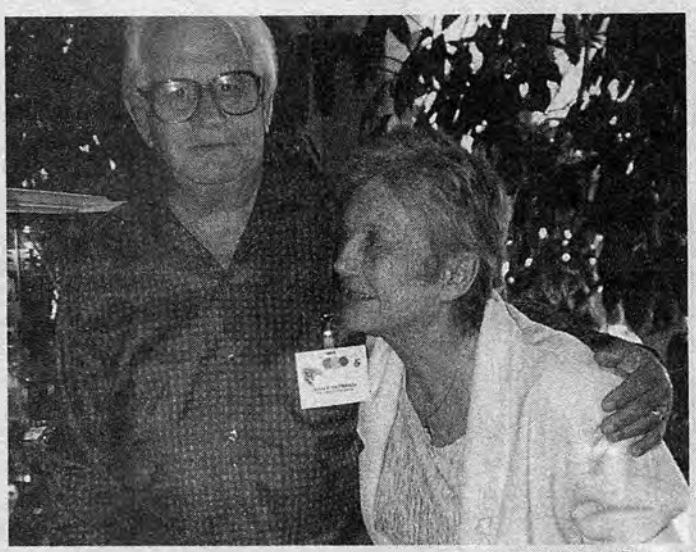
James Patterson in his laboratory with the first cold fusion cell patented in the United States.

Patterson has never witnessed X-ray emissions or neutron bursts. He claims that his cells produce between 500 and 600 percent excess heat, which is considerably higher than Cravens's more conservative estimate.

While Cravens believes that any complex chemistry that might be occurring under these circumstances would be endothermic, there are conceivable—if unlikely—complicated scenarios that might explain an exothermic reaction. Since the cells are not closed to the atmosphere, there may be complex organic compounds being formed in exothermic reactions. An example of such a compound would be formic acid (although the presence of formic acid itself in the cell is highly unlikely because it would have been noticeable for the stinging sensation even small amounts produce on human skin). Considering that the amount of excess heat involved (not the ratio) is quite low, it is possible that such complex chemical reactions could ac-

Inventor James Patterson

James Patterson, 73, has a long history as an inventor and his present cold fusion cell evolved from earlier experimental work. The resin beads, which are of his own unique design, have been a feature of many of his earlier patented inventions. As long ago as 1952, Patterson began working with metal beads built around a polymer core for water purification. At the time he was working as a physical chemist for Dow Chemical. He then used the beads to develop chromatography for an amino acid analyzer now used in DNA analysis.



Courtesy of James Patterson

James Patterson and Carol White.

In the 1970s, Patterson used the beads in order to measure different densities, by coating them with different amounts of nickel. This gave him a gradient marker for use with ultracentrifuges. For example, protein samples might be put in a cesium salt and then spun. The different proteins would settle at the interface of the cesium at the various densities, which could then be compared with the placement of a set of five nickel-coated beads, colored according to their densities. Patterson has more than 100 patents on these and similar inventions.

In the 1970s, he started working on hydrogen absorption for fuel cells. He coated the beads with palladium on top of the nickel, since palladium absorbs hydrogen readily. He was already retired in 1989 when he heard about the Fleischmann/Pons announcement of cold fusion. He tried to get in touch with them to offer his beads for study, but was unable to do so.

count for the appearance of excess heat production.

Temperature changes were slightly more than 2 degrees during the demonstration. Patterson had also placed the resistor which he used for calibration outside the tube, where it was surrounded by plaster of Paris (a feature of the design corrected by Cravens). Thus a good deal of energy was dissipated, making any attempt to calibrate the cell unreliable.

The beads take about 10 hours to load initially. The cell is run on a constant current somewhere between 1 or 2 amperes. Power input is about 0.5 watts, and the output is estimated by Cravens to be 1.7 watts. This is a conservative estimate, which does not make allowance for heat loss from the cell.

Patterson has four patents that cover the production of heat from the electrolysis of either heavy or light water, utilizing metal-coated polymer microspheres as the cathode. The patents specify that the CETI flow system owes its unique power production properties to the application of advanced polymer chemistry and thin-film electroplating methods. They do not discuss "cold fusion" but refer instead to "new hydrogen energy." Some believe this is why the Patent Office accepted the CETI application while rejecting the Fleischmann-Pons patents.

It seems to me that CETI has chosen to engage now in an extremely aggressive marketing drive. Undoubtedly Patterson is honestly convinced of the success of his experiment, and he has an impressive record as a chemist, but not in the field of calorimetry or electrochemistry. There are many, many questions still to be answered about his process. Perhaps his cells do produce a non-chemically induced excess heat when a heavy water electrolyte is used in place of light water, but that too remains to be seen.

Celani the Skeptic

No one appears to have followed up on Fleischmann and Pons' proposal at the Fourth International Conference on Cold Fusion at Maui last year that researchers investigate positive feedback effects associated with a rise in temperature. However, provided that loadings exceed a threshold of around .85, Fleischmann and Pons believe their experiments have demonstrated that a temperature rise is associated with an increase in the production of excess heat.

Fleischmann, Pons, and Italian physicist Giuliano Preparata also presented a paper at Maui discussing experiments conducted in the 1920s and 1930s by Alfred Coehn, which demonstrate that deuterium in a palladium lattice will be in an ionic rather than an atomic state. This is important if one wishes to promote a fusion reaction between deuterons (the positive ion of deuterium). Coehn had worked with palladium hydrides rather than with deuterium loading. He measured electronically what he believed to be the migration of protons down a very thin wire.

Several Italian groups have taken up this suggestion. Recent work by Giuliano Mengoli of the University of Padua corroborates a correlation between high loading ratios and a high diffusion rate of deuterons through a thin palladium wire. Mengoli collects the deuterium as it leaves the wire.

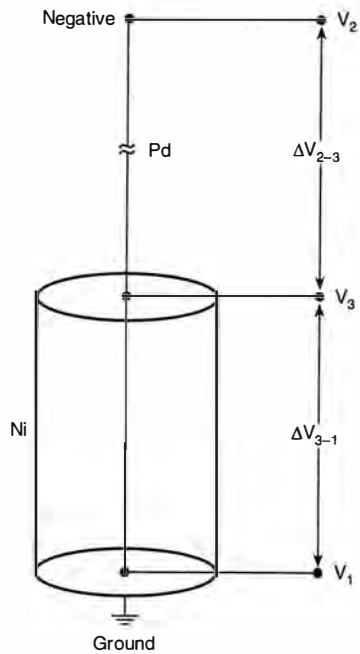


Figure 2
SCHEMATIC OF CIRCUIT FOR A CELANI CELL

Francesco Celani's electrolytic cell for loading a palladium wire and achieving electromigration, with a fast, high-power pulser at V_2 (not shown) and voltage monitors at points V_1-V_3. The wire segment with the voltage difference V_3–V_1 is for electrolysis and has a nickel anode. It serves as a source of deuterium. The segment with the voltage difference V_2–V_3 serves as a sink for deuterium in order to get electromigration of the deuterons. Celani reports a repeatably high excess heat from loading the thin palladium wire.

This past year, Francesco Celani of the Italian National Institute of Nuclear Physics at Frascati has conducted a series of very interesting experiments using an adaptation of the Coehn experimental configuration. He reports that he gets a repeatably high excess heat. His cell employs a thin palladium wire with a diameter between 100 and 500 microns, and a length varying from 5 to 100 centimeters.

Celani reports that excess heat occurs with high repeatability after only 300 seconds. He has a power amplification of around 160 percent, with a power excess of 5 watts. This scales up to something in the range of 1 kilowatt per square centimeter of cathode surface area. Increasing the length of the wire appears to increase the amount of excess heat produced. There is a voltage drop along the wire, which he considers to be a critical parameter for his experiment.

Another surprising result is that Celani estimates that it takes only 200 seconds to load the wire to a .8 loading ratio. He takes several measures of the resistance ratio along the wire in order to estimate the loading. He finds that the measured resistance follows the typical Baranowsky curve, as extended by McKubre. It goes to a maximum at around .8 and then drops to a minimum at an estimated loading of 1.1, but then the resistance begins to rise, indicating to Celani that the wire has begun to deload. The whole cycle takes only 80 seconds.

Celani speculates that several phase transitions in the palladium may be occurring. In his view, the high voltage is what allows him to rapidly achieve high loading. Use of pulsed power prevents overheating of the wire, while not allowing excessive deloading. He also believes that the configuration which he has chosen minimizes recombination of the deuterons to form deuterium molecules.

Peak currents as high as 120 amps are applied with an 800 nanosecond pulse, which is repeated at a rate of between 1,000 and 20,000 hertz, depending on the particular experiment. The wire also functions as a typical cathode, bathed in an electrolyte of lithium deuteroxide and heavy water.

The current density of the pulse along the wire is between 50,000 and 300,000 amps per square centimeter of the wire's cross-section, and the electrolysis current would then be between 10,000 and 100,000 milliamps per square centimeter. This compares with the typical value of 64 to 1,000 milliamps per square centimeter.

A skin effect at the near surface circumference of the wire may also enhance excess heat production.

Celani cold-works the wire and has also tried coating it variously with lead, borosilicate, and even nickel. He uses a nickel anode. McKubre reports that in every instance in which he used a nickel anode, he did not get excess heat production because nickel would then be deposited on the cathode. In the Celani experiment, however, much higher voltages are applied, which might affect the ability of deuterium to penetrate the palladium despite the presence of the nickel. (McKubre also reports that he never achieved excess heat unless there was silicon present in the cell. The significance of this is not really clear.)

The nickel anode is grounded, and one segment of the palladium wire is used as a cathode while the other segment is left floating (Figure 2). The part of the wire involved in the electrolysis is just a fraction of the length, being 1/4, 1/10, and 1/20 in different experiments.

A calibration pulse was introduced every six hours using a 1-watt internal heater. A thermocouple is located between the anode and cathode and the heat radiated out is measured. Since the cell is maintained at room temperature rather than in a water bath, this is a rather inefficient method of isoperibolic calorimetry, in which transient factors can disrupt the accuracy of measurement significantly.

The experiments run successfully for two to three weeks and could go longer. Celani stops them only as a matter of convenience. He is naturally excited about his results but he describes himself as a *skeptic* in contrast to CERN physicist Douglas Morrison whom he calls a *be-*

liever, because Morrison is convinced that cold fusion is impossible despite any evidence to the contrary.

A Function of Flux

Many people over the years have speculated that some form of disequilibrium is needed in order to trigger the experiment. Typically, Fleischmann and Pons ramp up current and also introduce frequent heat pulses. Akito Takahashi of Osaka University (and a number of experimenters who have repeated his experiment successfully) alternates between high and low current densities. Celani introduces a rapid current pulse. Others apply radiowaves. The occurrence of vigorous bubbling in an electrolysis experiment may play a similar role.

This past year the SRI group went over their experimental data in order to see whether they could pin down such an effect. They looked closely at two experiments done under comparable conditions. One (M4) was a new experiment done in October 1994; the other (C1) was from data taken in December 1991. The correlation is between the amount of deuterons flowing in and out of the palladium, through the interface, and the amount of excess heat produced. This flux would occur over a period of two hours. Excess heat was produced in one of the experiments even though the loading ratio was relatively low. It appears that in this experiment a higher variation in the loading compensated, so that the excess power densities were equivalent in both experiments.

For excess heat to be produced, it was necessary to maintain a loading ratio above a threshold of approximately .85. The deuteron flow into and out of the palladium functions as a kind of fluctuation that might be likened to the cathode breathing. Other parameters of the experiment also had to be met. The current had to be 100 to 400 milliamps per square centimeter. An initiation time of around 300 hours was necessary as well. It also appears in these experiments and experiments performed at IMRA-Japan, that there is a correlation between the square of the loading above the necessary threshold value and the production of excess heat.

When these factors are taken together—a linear relationship of excess heat to current density, a parabolic relationship of excess heat to loading, a proportionality constant, and then another term representing the flux of deuterons through the interface associated with desorption/adsorption—they combine in an .87 correlation with excess heat production.

The obvious question to be investigated, assuming that this correlation is real, is whether the fluctuation reflects the production of excess heat, or whether perhaps it creates conditions that promote a cold fusion reaction.

There is a certain amount of agreement among groups such as SRI, the IMRA Material cold fusion research team, Kunimatsu's IMRA-Japan lab, and the New Hydrogen Energy (NHE) laboratory in Sapporo, Japan, on some of the conditions necessary to achieve excess heat, but there are also important areas in which they disagree.

Controlling the Palladium

Unfortunately, McKubre's group at Stanford Research Institute (SRI) did not have any significant new experimental results to report on materials and loading. This may be partly because the group had been mandated by its sponsor, the Electric Power Research Institute (EPRI), to search for a correlation between excess heat and some nuclear ash. Considering that the SRI group is made up of top-level electrochemists, not nuclear physicists, such an excursion from their area of expertise was most likely a waste of their efforts. The EPRI managers perhaps made the mistake of allowing the critics of cold fusion to set their agenda.

The SRI team has also been left with a much reduced level of funding. Because the EPRI nuclear division sponsoring the SRI cold fusion team has come under severe financial pressure in the recent reorganization there, this is understandable but deplorable. Not only did the SRI team have to cut back on the ambitious experimental program they had planned, but they also had to spend time in replacing some of the lost funding.

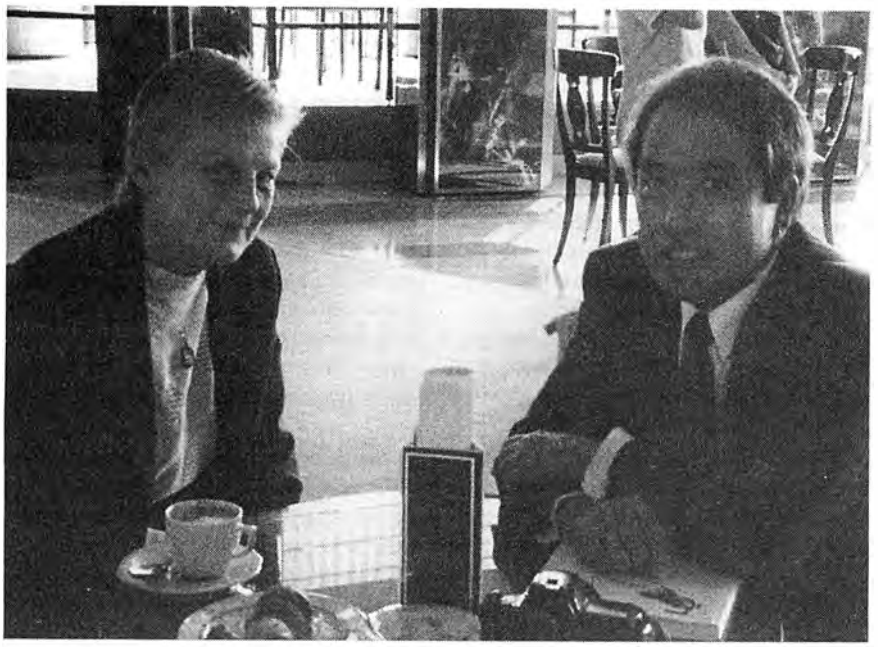
On the question of the continued irreproducibility of the experiment, McKubre distinguished between irreproducibility of results, and the problem of reliably achieving the necessary preconditions for a successful experiment. He raised the question, "Why can't we obtain the loadings that we need in all experiments?" In partial answer, he produced an analysis of 214 experiments, done over 200,000 hours. He found a great variation in the apparent quality of batches of palladium; nonetheless even certain batches of apparently poor quality (from the vantage point of cold fusion experiments) could be made to produce excess heat when deuterated, provided that they received certain pretreatments. The addition of 200 ppm of aluminum to the electrolyte, for example, favored success.

McKubre also described how the material was improved by mechanically removing a skin of metal from the palladium cathode. In his view, this was a way of removing surface impurities and damage. (Edmund Storms agrees that machining the metal is useful, but for the opposite reason. In his view, useful dislocations are added to the metal.) After machining, he anneals the palladium, which improves its crystalline structure and creates a more homogeneous grain.

Cooperation has been ongoing between the SRI group and Keiji Kunimatsu's laboratory, IMRA-Japan. More recently McKubre has also been cooperating with IMRA Material, an independent group within the IMRA consortium, which produces palladium cathodes. Hiraku Okamoto reported on studies conducted at IMRA Material to determine how to improve the characteristics of the palladium.

Okamoto's group had done a series of electrolysis experiments to determine the conditions necessary to achieve a high loading ratio. Much of their methodology is like that used at SRI and also at IMRA-Japan. Unlike Edmund Storms and Francesco Celani, who both favor oxidizing the metal surface, they found it to have a deleterious effect, perhaps because theirs was a thicker layer. McKubre, who on occasion pretreated the palladium by anodic (rather than high temperature) oxidation, found it to have a deleterious effect on the attainment of loading. In the case of Celani's experiment, such a difference is certainly understandable, since he applies extremely high voltages so that an oxide layer on the surface of his thin metal wire would not act as a barrier to the loading of deuterons, as might otherwise be the case.

The intent of the experiments was to make a metal stock that would allow high loadings in order to increase the reproducibility of the experiment. They



The author with Hideo Ikegami, professor of physics at Nagoya University and member of 21st Century*'s science advisory board.*

tried to test bulk properties of the palladium, as well as the effects of surface modification. Like McKubre, they found that annealing also improved the quality of the material, as did polishing it. Perhaps surprisingly, the purity of the palladium did not appear to influence loading ratios.

It is interesting that the New Hydrogen Energy (NHE) laboratory, at Sapporo in Japan, obtained somewhat different results from its study of palladium, according to the report given by M. Takahashi.

The NHE group also studied the conditions needed to achieve high loading. When they compared annealing the palladium to cold working, they found no significant difference. Their best loading came using the single-crystal palladium, but this produced no excess heat. They found that the single crystals did not deload readily.

Perhaps this indicates a relationship between deloading and production of excess heat along the lines of McKubre's flux function. In the NHE case the highest loadings did correlate to the purity of the material. It may be that it is the position of the impurities which is crucial, for example whether they be at the surface or at grain boundaries.

There is an interesting comparison which came out of Takahashi's discussion between the rapid desorption which is found in cold-worked materials and the slow desorption from single crystals. The single crystals are produced by annealing, and have no grain boundaries. Cold working also disrupts grain boundaries but in a different manner.

Since cold working stresses the material, it can increase cracking, as well as increasing dislocation sites. It is not at all clear yet what the effects are—positive or negative—of the existence of dislocation sites and/or impurities in the metal.

Obviously, the degree to which cracking does or does not occur is crucial. The deposition of a layer of highly concentrated lithium, which Makoto Okamoto and his associates have found to be concomitant with excess heat production, may actually be functioning as a marker for the quality of palladium, rather than playing some role in furthering production of excess heat. A lower concentration gradient would be indicative of diffusion because of cracking.

The MITI Project

This was the first year of the New Hydrogen Energy project, sponsored by MITI, the Japanese Ministry of International Trade and Industry. This first year was largely devoted to setting up a laboratory in Sapporo, Japan, and establishing a working group. Along with loading studies and certain materials testing, two parallel programs were run testing the fuel cell anodes developed by Keiji Kunimatsu at IMRA-Japan and in running very low power Fleischmann-Pons cells in the first stage of what they call the Icarus project.

N. Asami, who heads the NHE laboratory, gave an overview of this first year of operation. In three cases the Kunimatsu cells produced measurable excess heat of 7 to 15 percent. The palladium, with a purity of 99.93 percent, was loaded to .89.

The foundations for an ambitious research program have been laid. Next year the MITI program will be subject to an overall review in which it is expected that certain benchmarks will be met for definitively establishing the production of excess heat.

The NHE group will study Fleischmann-Pons cells which are brought to conditions of near boiling—Icarus II—as opposed to the very low energy-input cells which they have studied over the past period. They will also look at the McKubre cell design as well as some of their own devising.

As Asami pointed out, however, the purpose of the project is not only to confirm and demonstrate excess heat, but to make clear what the heat generating mechanism is and how it can be controlled. Both of these steps are recognized by the Japanese as essential if cold fusion is to be a future energy source. The NHE laboratory is at the center of MITI's national effort, which includes cold fusion research efforts in many major Japanese universities, and also in industry groups.

While the detailed discussion of materials questions, or issues involved in the detection of nuclear particles and X-rays—taken up at the conference by Russian and Italian researchers—may not be glamorous, they are absolutely crucial at this point, and to my mind were the best feature of the conference.

Next year, the Sixth International Conference on Cold Fusion will be held in Sapporo, under the sponsorship of MITI. This time the plan is to support attendance by young researchers who are interested in cold fusion but who have not been able to attend the conferences because they lack financial support.

Fleischmann and Pons

Although the conference was hosted by Martin Fleischmann and Stanley Pons, unfortunately they chose to shroud

their most recent work behind a veil of mystery. Have they hit the jackpot, or are their current results disappointing?—a question on everyone's lips, for which they provided no answer.

They chose not to present any of their own data at this conference; however, Fleischmann did present some data from the NHE experiments in order to show qualitative indications that there was some excess heat being produced. Mainly he wished to make the case that certain small heat excursions indicated a phase transition of the palladium from exothermic to an endothermic. His aim was to demonstrate how, in this case, a positive feedback mechanism exists which enhances the production of excess heat.

The data that Fleischmann showed could give only qualitative indications, since the power input was over 1 watt, and the range of fluctuation was on the order of milliwatts. He assumes that the introduction of a heat pulse every six hours—important in order to calibrate the cell—actually plays a causal role in promoting the experiment. Analyzing the cooling curve after such pulses, he believes he sees indications of both an endothermic phase shift and excess heat production, although this could not be established quantitatively in these experiments.

The first and second curves that he chose to compare were taken from data collected at times 6 days and then 25 days apart. Explaining his point, he said: "You see the relaxation of the temperature-time curve in response to the calibration pulse. Now look 25 days down, you see the same sort of data. But if you look at the intermediate time, then you see a very curious feature of the calibration and that is that now you have a long tail. The temperature continues to increase, so the temperature is increasing in response to the calibration pulse. If the temperature is increasing, the heat output is increasing, and that is positive feedback. . . ." He explained that such positive feedback is necessary if the system is to be operated at elevated temperatures.

Fleischmann's talk was certainly a disappointment to those who wanted a peek into his laboratory, but as we have seen in the past, he is always worth taking seriously. There has yet to be a systematic exploration by any other laboratory of how raised temperature does affect loading and excess heat production, although Edmund Storms did find an interesting corroboration of the experiment in his unfortunately short-lived last series of experiments.

Eichi Yamaguchi detected helium-4 and other fusion by-products in an experiment of his own design, while working for NTT. His experiment was successfully replicated by Yasuhiro Iwamura's team at Mitsubishi Heavy Industries' Advanced Technology Research Center. They were able to detect neutron bursts and tritium emissions occurring simultaneously, but not helium-4. The definitive proof that Iwamura's team had detected tritium was presented at ICCF5.

Yamaguchi and Takahashi

At the Third International Conference on Cold Fusion, Eichi Yamaguchi announced that he had detected helium-4 among other fusion byproducts in a unique experiment of his own design. At the time he was working at an NTT laboratory located in Japan, but he is at present involved in setting up an expanded laboratory facility on the premises of IMRA-Europe and has not yet been able to assemble the equipment necessary to continue work on this particular experiment.

However, Yamaguchi's experiment was successfully replicated, as announced at the Fourth International Conference on Cold Fusion last year at Maui, by Yasuhiro Iwamura, who heads a cold fusion research team at the Advanced Technology Research Center of Mitsubishi Heavy Industries. They were able to detect neutron bursts and tritium emissions occurring simultaneously, but not helium-4. The evidence for tritium was the presence of mass-5 molecules detected using a high-resolution quadrupole mass spectrometer for gas analysis.

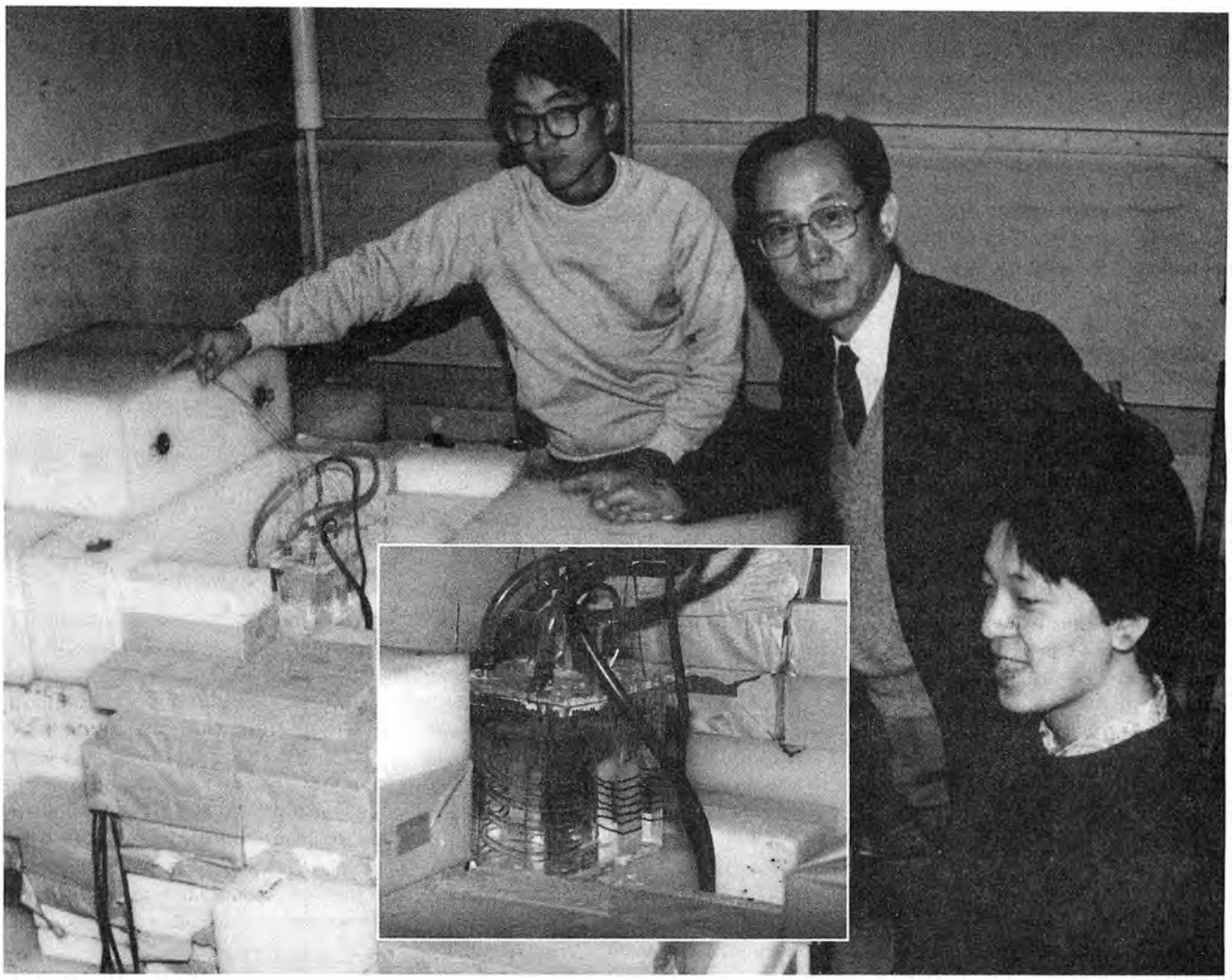
Yamaguchi, although pleased with the experiment, pointed out at Maui that Iwamura's team could have detected a triply compounded D-D-H molecule, also mass five, rather than a D-T molecule. A molecule of deuterium and hydrogen would not indicate a fusion reaction. This year they presented definitive proof that what they detected was indeed D-T molecules.

The experimental design used by Iwamura's team is much like that of Yamaguchi. A palladium plate (25 × 25 × 2 mm) is loaded with deuterium gas in a vacuum chamber over a period of more than a week to an estimated ratio of .66. Then a thin film of gold or aluminum is deposited onto both surfaces of the plate in order to slow the rate of deloading. The samples are then heated to induce rapid diffusion of the deuterium from the plate.

In 1991 and 1992, Akito Takahashi, a nuclear physicist at Osaka University, had dramatic success with a cold fusion electrolysis design that has since been copied all around the world. Using a thin palladium plate, he employed an al-

Carol White

Yasuhiro Iwamura addresses the ICCF5.



Akito Takahashi of Osaka University (center) with his cold fusion electrolysis cell. The cell produced excess heat correlated with the production of neutrons and tritium, and has been successfully replicated several times, although with much lower excess heat. He is now repeating his experiment with a much more sophisticated calorimeter and simultaneous blank experiments. If the level of excess heat he originally observed proves to be repeatable, this extremely precise and accurate series of experiments should undermine the last pretensions of the critics that positive experimental results are merely artifacts.

ternation of current density in what he termed high and low current modes, and not only produced high excess heat, but was able to correlate this with neutron flux and tritium emissions. His experiment has been successfully replicated several times, although with much lower excess heat. (See *21st Century,* Summer 1992, p. 63.)

Since he has a cold fusion theory involving multi-body fusion, he has occupied himself with other experiments in the intervening period, intending to demonstrate particular characteristics that would substantiate his theory. Most recently he decided to repeat his original experiment, this time with a much more sophisticated calorimeter, and simultaneous blank experiments. The Jan. 17 earthquake stopped his work for a period of months just as it had begun to show interesting results.

Takahashi's setup consists of simultaneous and parallel test runs to detect foreground and background neutron emissions and possible X-ray emissions, and to compare palladium versus nickel cathodes, using both heavy and light water. One power supply for electrolysis is shared between the working and the blank cell, so that the electric current supplied will be identical. There is similar mass flow calorimetry for both cells.

He estimates the loading ratio in his cells to be around .9 for the low mode, in which the current is .5 ampere. The loading decreases to .8 during the operation of the high mode, where the current exceeds 1 ampere, in cells using cold-worked palladium. However, in cells with annealed palladium there was an increase of the D/Pd loading ratios up to .95.

After the cells had run for more than 18 days, a trend of excess power generation in the palladium cell was observed, as compared with the nickel cathode cell (both used heavy water). This trend continued for 260 hours. By taking the Gaussian distribution curve for both cells over the whole period of the experiment, they could establish a 99 percent confidence level. They observed 2.3 to 3.5 watts of excess power, with an error

band of .65 watts. The excess power ratio however was only 5 to 7 percent. No such power excess was seen in the nickel blank.

No X-ray emissions were observed in either cell, and there were only slight indications of neutron emissions in the palladium cell. These were extremely weak and were not correlated with excess power generation. X-ray emission may have been attenuated by the 1 mm thick palladium cathode plate. On the other hand, Takahashi considers the level of excess heat is still too low to definitively rule out some as yet unidentified systematic error.

Takahashi's experimental program has been resumed now that the earthquake damage has been repaired. If the level of excess heat which he observed before the earthquake proves to be repeatable, as there is every reason to believe will happen, then this extremely precise and accurate series of experiments should undermine the last pretensions of the critics that positive experimental results are merely artifacts.

In Conclusion

It is said that the probability of a cold fusion event is 10^{42} according to the norms of generally accepted quantum theory. More to the point is the reverse assertion: Clear evidence of excess heat production above and beyond any known chemistry allows us to turn the tables and assert that it is the present-day theory that is improbable!

The problem with all serious theoretical efforts at the present time-ignoring forays into alchemy, telekinetics, and other similar rococo excursions into the New Age-is that they attempt to splice together conventional models and one or more "strange" assumptions which might account for the occurrence of cold fusion despite the stringencies of the Coulomb barrier and so forth.

One might describe these various assumptions, collectively, as magic bullets or as *dei ex machina*. What is needed is a Planck or Einstein to overturn the whole applecart. When this happens, then a whole new world of science and technology will open up. Chemistry and physics will have to be reconsidered as one scientific discipline. Then it will become possible, routinely, to accomplish genuine transmutations of elements, in a way that would have astounded and delighted Mendeleyev.

Laser Cooling

Continued from page 55

the vertical plane (see figure).

Such setups allow researchers to cool atoms to 1 μK. To cool the atoms further, other techniques are employed. In August 1994, scientists at NIST announced that they had been able to cool cesium atoms to 700 nanokelvin (nK)—700 billionths of a degree. This is the lowest temperature yet for 3-dimensional laser cooling.[2]

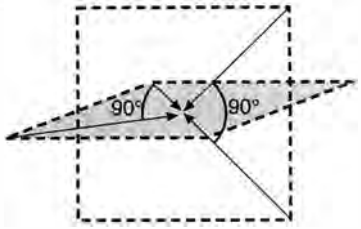
In NIST's technique of adiabatic cooling (without loss or gain of heat), the intensity of the lasers is gradually lowered to allow the tiny cloud of atoms to expand slightly, which also cools them. At these temperatures the atoms are moving at only 7 millimeters per second.

Borrowing the Bragg scattering technique from crystallography, the atoms trapped in the optical lattice can be probed. Scientists can infer the position and motion of the atoms by shining a laser into the atoms after the confining beams are switched off, and then measuring the amount of scattered light. Rolston reports that only about 1 percent of the sites in the optical lattice are filled, yielding a density of 8×10^{10} atoms/cm^3. The amount of reflected light, about .2 percent, is several orders of magnitude higher than for a normal lattice, with randomly spaced atoms, at the same densities, Rolston says.

Atomic Clocks and Atomic Fountains

One of the main interests of NIST in laser cooling and trapping of atoms is to aid in constructing more accurate atomic clocks. By measuring the characteristic frequency of cesium atoms driven by microwaves, one can obtain a very precise standard for time. NIST's best atomic clock is accurate to 1 part in 10^{14}, or 1 second in 3 million years. The limiting factor tends to be the amount of time the atom has to interact with the microwave field. For current clocks that is just tens of milliseconds at best. If the time that the atoms spend in the field could be increased by slowing them down, then the signal from the atoms would be much sharper.

NIST intends to build a clock using ultra-cold atoms that are cooled and trapped in an optical lattice and then launched upward by another pair of beams into the microwave chamber at the leisurely rate of a few meters per second. The rise of the atoms of this atomic fountain, as it is called, is slowed by gravity so that the atoms stop and fall through the microwaves again. The total time the atom spends in the field is increased 20- to 100-fold over conventional systems, with a corresponding improvement in accuracy.



COOLING AND TRAPPING ATOMS WITH A FOUR-LASER ARRAY

For some experiments, NIST uses a four-laser configuration to create a more stable optical lattice in which cold atoms are trapped. Two laser beams cross each other at 90 degrees in the horizontal plane. Two other laser beams, also at 90 degrees, intersect the first two lasers from the opposite direction in the vertical plane.

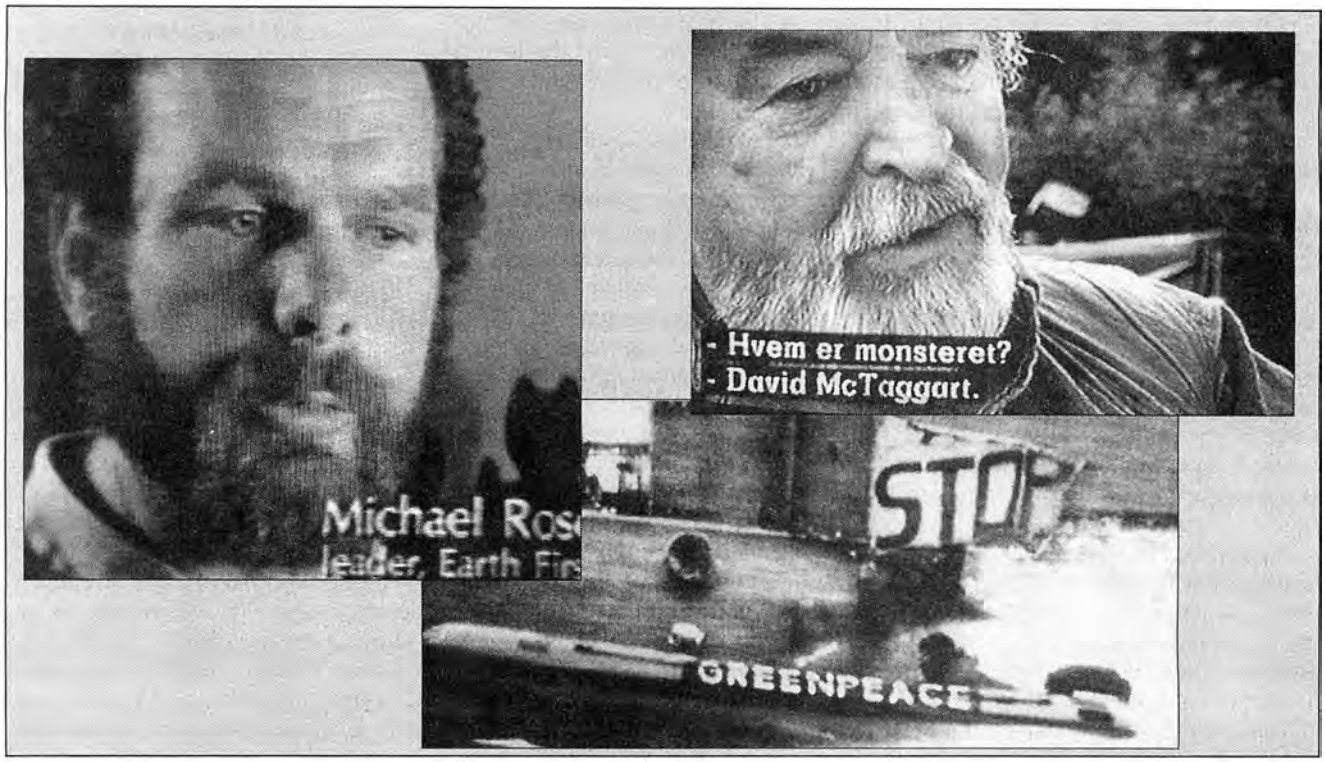
Steven Chu and his group at Stanford University in California, who have also done pioneering work in laser cooling, have used an atomic fountain to build extremely sensitive devices for measuring variations in the Earth's gravitational field to aid in geologic and seismic research.

Another area to which NIST and other researchers are turning their attention is that of laser manipulation of atoms. It is possible that laser beams can be used to produce patterns that would enable researchers to direct atoms onto surfaces. In the future this approach could then place atoms in such a way as to produce structures for microelectronics circuitry, for example.

Notes

1. The Doppler effect is the change in the observed frequency of an acoustic or electromagnetic wave due to relative motion of source and observer.
2. Also in 1994, ENS, the Ecole Normale Supérieure in Paris, reached 240 nK in two dimensions, and JILA, the Joint Institute for Laboratory Astrophysics, Boulder, Colorado, along with NIST and the University of Colorado, succeeded in cooling atoms of rubidium-87 to 200 nK, using a magnetic trap.

Court Affirms Greenpeace Ties to Earth First! Terrorists



Scenes from the Danish documentary, "The Man in the Rainbow": Bennett Metcalfe (top right) calls David McTaggart, the former head of Greenpeace International, a "Frankenstein monster"; a typical Greenpeace action; Earth First! leader Mike Roselle, who makes no secret of the group's terrorist activities.

Just as the Washington, D.C., bureau chief of Greenpeace was insisting in a letter to *The Washington Times* that his organization was based on "non-violence," a state court in the German city of Hamburg ruled July 28 that "The collaboration of Greenpeace with the terrorist organization Earth First!" cannot be denied. A three-judge panel, presided over by Judge Krause, issued the ruling in case 3240556-94, a libel suit brought by Greenpeace.

The Hamburg court ruling is one of several blows that have punctured Greenpeace's friendly, money-raising facade:

• *Executive Intelligence Review (EIR),* the LaRouche political weekly, documented in October 1994 how Greenpeace—which brags about its "independence"—is in reality just the direct-action arm of the international environmentalist movement, run top down by Prince Philip and the House of Windsor and its allies for the purpose of reducing the world's population and destabilizing political opponents of the European nobility. (This expose´ was excerpted in the Winter 1994 issue of *21st Century.*)

• Greenpeace lost a series of lawsuits in Paris. (See *21st Century,* Summer 1995, p. 4.)

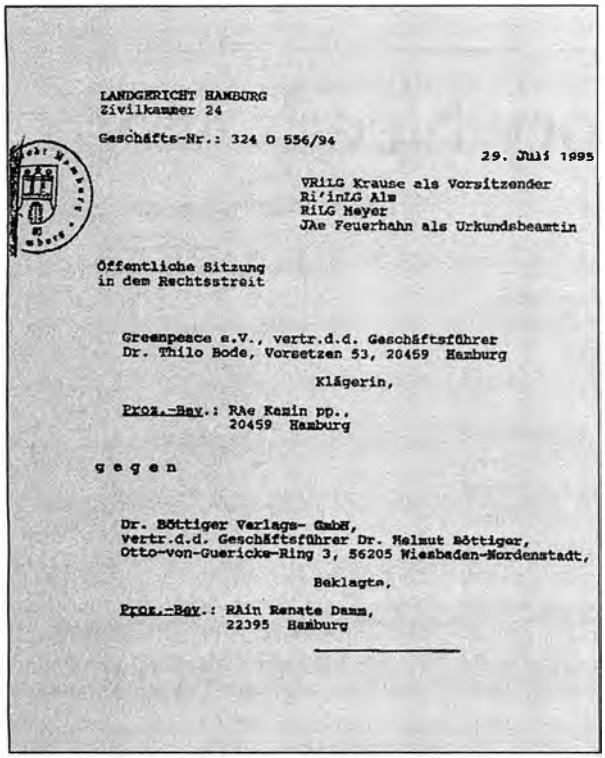
• Two other recent court decisions in Germany went against Greenpeace: one that concerned Greenpeace's Earth First! terrorist connections and a second that concerned the founder and former head of Greenpeace Germany, Monika Griefahn, now the Environment Minister in the state of Lower Saxony. Griefahn was accused of using her influence to get business contracts for her husband.

Terrorist Links

Most startling is the evidence that the "non-violent" Greenpeace has been working both openly and stealthily with Earth First!, a group that advocates using terrorist tactics to achieve its environmenalist agenda.

The U.S. press has picked up on the story that a "hit list" appeared five years ago in the underground newspaper *Live Wild or Die,* which is distributed by members of Earth First! Two of the top three names on this "Eco-F***er Hit List" have been recent victims of the so-called Unabomber.

A copyrighted article in the Aug. 3 issue of *The Sacramento Bee* states that the information on Earth First! was docu-



LANDGERICHT HAMBURG
Zivilkammer 24

Geschäfts-Nr.: 324 O 556/94

29. Juli 1995

VRiLG Krause als Vorsitzender
RiinLG Alm
RiLG Meyer
JAe Feuerhahn als Urkundsbeamtin

Öffentliche Sitzung
in dem Rechtsstreit

Greenpeace e.V., vertr.d.d. Geschäftsführer
Dr. Thilo Bode, Vorsetzen 53, 20459 Hamburg

Klägerin,

Prozv.-Bev.: RAe Kamin pp.,
20459 Hamburg

gegen

Dr. Böttiger Verlags- GmbH,
Vertr.d.d. Geschäftsführer Dr. Helmut Böttiger,
Otto-von-Guericke-Ring 3, 56205 Wiesbaden-Nordenstadt,

Beklagte,

Prozv.-Bev.: RAin Renate Damm,
22395 Hamburg

The Hamburg court decision.

mented by Barry Clausen, a private investigator in Seattle who had infiltrated Earth First! in the early 1990s. Clausen also provided detailed documentation of the connections between Greenpeace and the terrorist Earth First! Many Greenpeace leaders, he found, are also leaders of Earth First! and the two groups hold joint environmental actions.

The Hamburg Case

The July 28 German court ruling concerns a small publishing company in Wiesbaden, Boettiger Verlags GmbH, which is known for its publication of scientific material debunking environmentalist hoaxes, including a German-language edition of *21st Century*'s popular book, *The Holes in the Ozone Scare: The Scientific Evidence That the Sky Isn't Falling*, by Rogelio Maduro and Ralph Schauerhammer. Boettiger also publishes the newspaper of the political movement in Germany associated with Lyndon H. LaRouche as well as LaRouche's books.

Greenpeace brought a libel suit in Hamburg in August 1994 against a press release issued by Boettiger inviting the press to a viewing of "The Man in the Rainbow," a documentary produced by the Danish state television network, TV-2, and broadcast in Denmark on Nov. 14, 1993.

Produced by Nordisk Film with Icelandic filmmaker Magnus Gudmundsson as special consultant, the film exposes how Greenpeace was transformed from a small action group into a multinational business corporation with a multi-million-dollar annual budget, how Greenpeace bribed officials of several governments in order to pack the International Whaling Commission with member nations that would support the controversial ban on commercial whaling, and how Greenpeace maintains close connections with the ecoterrorist organization Earth First! The film also includes interviews with Greenpeace's former accountant, who discusses financial irregularities and secret bank accounts in the names of individual Greenpeace leaders.

The German state broadcast network, Norddeutsche Rundfunk, had bought the broadcast rights to the Danish film in Germany but then showed no intention of broadcasting it. After several months, Boettiger decided to hold a press conference April 24, 1994, to show journalists a video of the documentary. Because the state broadcast network owned the broadcast rights in Germany, the place chosen for the press conference was the town of Bov, Denmark, which is near the German border. Boettiger sent a press announcment of the coming event that described the film.

Greenpeace issued a so-called fact sheet that slandered Boettiger and the LaRouche organization, mentioning the planned press conference in Bov. Then, on Aug. 26, 1994, Greenpeace filed a libel suit against Boettiger over the press release on the documentary and demanded an 80,000 deutschemark penalty ($60,000).

Also in August 1994, Earth First! leader Mike Roselle reported in the *Earth First!* journal (p. 23) that he traveled to Amsterdam and "spoke with Steve Sawyer, chairman of the Greenpeace International board of directors, about this [the Danish documentary] and tried to console him. 'It was bad enough that they were using Earth First! to slander Greenpeace in Europe' I said, 'but in Idaho they're using Greenpeace in an effort to discredit Earth First!' After getting things cleared up with their Washington D.C. office, Greenpeace is now trying to tell the courts and the European public that they aren't the scumbags the movie says they are and that they are proud to work with us when they can. If they show the movie again, Greenpeace will sue for libel." ▶

Earth First!

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—Mike Roselle in the August 1994
Earth First! journal

A Split Decision

The court decision on the case was split. First, and most important, the court ruled that Boettiger's statement that the film proves "the collaboration of Greenpeace with the terrorist organization Earth First!" cannot be denied. Second, the court ruled that the press release statement that Greenpeace had "diverted contributions to the accounts of independent organizations which were privately accessible to a tiny number of the top functionaries," was not proven to its satisfaction.

Greenpeace has a history of squelching exposés of its unsavory activities by telling lies, strongarming opponents, and using its multi-million-dollar budget to force critics into costly lawsuits. But now the cracks in its friendly public image are getting too big to hide.

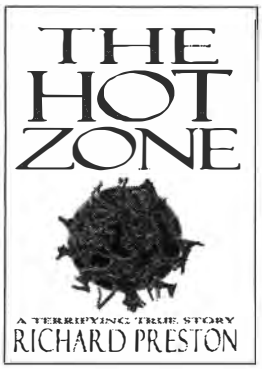
Third, the court ruled that the Boettiger press release statement that the former head of Greenpeace International, David McTaggart, had "built up the environmental organization into a business based on fears for the environment [Umweltangst]" could not be denied. The court found, however, that the "criminal history of Mr. Greenpeace [McTaggart]" to which the film and the release referred—his arrest and jailing in New Zealand on smuggling charges—was outdated and could no longer be held against him.

It should be noted that even this split decision in the Hamburg court is remarkable, both because Hamburg is the site of Greenpeace's headquarters in Germany, where there is strong sentiment supporting the group, and because the judicial district there is notoriously tough on the issue of journalists and free speech. (For example, a journalist there was recently sentenced to six months in jail or a hefty fine for saying that the chairman of the former East German Communist Party, Gregor Gysi, was an informer for the Stasi, the East German secret police.)

—Geoffrey Steinherz and Marjorie Mazel Hecht

BOOKS

Ebola Story Needs More Science



The Hot Zone: A Terrifying True Story
Richard Preston
New York: Random House, 1994
Hardcover, 300 pages, $23.00

A medical chiller-thriller, written in a gripping and sensationalist style, *The Hot Zone* is all the more fascinating because the story is true. In early winter 1989, the deadly hemorrhagic virus, Ebola, broke out in a monkey colony housed by Hazelton, a monkey import company, in Reston, Virginia, just outside of Washington, D.C. A SWAT team in biohazard space suits was called in from Fort Detrick, Maryland, to contain the outbreak.

For those who don't mind the gore, the book is enjoyable reading—*except* for the peculiar Gaia ideology that Richard Preston has woven into his chilling tale, investing nature with human attributes. For example, Mount Elgon in Kenya, site of the infamous Kitum Cave from which two humans became infected with Ebola, is compared to "an empty cathedral," after poachers killed most of the vast herds of elephants that once inhabited the area. And African cedar trees are likened to a "choir" growing around the mouth of Kitum Cave.

Worse, Preston depicts mankind as a disease despoiling nature: "The emergence of AIDS, Ebola, and any number of other rainforest agents appears to be a natural consequence of the ruin of the tropical biosphere. . . . In a sense, the earth is mounting an immune response against the human species. It is beginning to react to the human parasite, the flooding infection of people, the dead spots of concrete all over the planet. . . ."

This is very colorfully written, but hardly a scientific hypothesis.

The Selenium Factor

That said, there is one fascinating scientific question that is posed by *The Hot Zone:* Ebola Reston and Ebola Zaire are so genetically similar that scientists are hard put to figure out what the difference is. Yet, Ebola Zaire in Africa kills 90 percent of the human beings exposed to it, while Ebola Reston, which all four monkey caretakers at Hazelton Research Products had in their bloodstream, created no symptoms in those individuals but devastated the crab-eating maçaque monkeys housed in the monkey colony there. Why? And why did some doctors treating Ebola patients in Africa fail to come down with Ebola, although they were definitely exposed to the virus via surgical cuts or needle sticks?

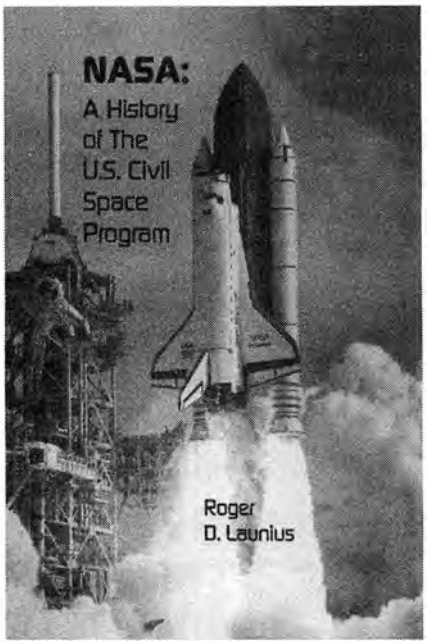
Perhaps a hint of an answer is to be found in the work of Dr. Will Taylor at the Department of Medicinal Chemistry at the University of Georgia in Athens. Taylor has found evidence that HIV, Coxsackie, and *possibly* even Ebola all use proteins containing selenium to keep themselves in a dormant state. In a host whose diet is rich in selenium, such as the Reston monkey handlers or European doctors working in Africa, perhaps the selenium keeps the Ebola virus from replicating long enough for the immune system to mount an adequate attack.

Because the amount of selenium in plant foodstuffs varies tremendously, depending on its availability in the soil in which the plant was grown, meat is the best buffer to maintain adequate selenium in the human diet. The area around the Ebola River—which is where both HIV and Ebola were first discovered—is known for low levels of selenium. In addition, there may be a method in the madness of troops of maçaques binging on crabs in the mangrove swamps, for seafoods are also an excellent source of selenium.

—Carol Hugunin

A Unique History of NASA

NASA: A History of the U.S. Civil Space Program
Roger D. Launius
Malabar, Fla.: Krieger Publishing Co., 1994
Hardcover, $16.50, paperback, $12.50,
276 pages



One advantage to being the chief historian of the nation's space agency is that you have easy access to the treasure trove of historical documents that reveal the behind-the-scenes discussions and decision-making that we see only as the final product in the accomplishments of the space program.

NASA historian Roger Launius has compiled an interesting selection of original source material to make this history a unique one. The first half of the book is a brief overview by Launius of the history of interest in space from the ancients to the present day. The second half of the book consists of historical documents that Launius refers to in his text.

Some of the readings are accessible to the interested reader in previously published books—for example, the Act of Congress creating NASA—but it is handy to have a number of these documents in one place. Other documents are less well known but most interesting.

One such is a document written by Vice President Lyndon Johnson on May 13, 1963 at the request of President Kennedy, to respond to congressional criticism of the Apollo program. The document states: "It cannot be questioned that billions of dollars directed into research and development in an orderly and thoughtful manner will have a significant effect upon our national economy. No formula has been found which attributes specific dollar values to each of the areas of anticipated develpments, however, the 'multiplier' of space research and development will augment our economic strength, our peaceful posture, and our standard of living."

The same document goes on to list a number of fields that will obtain substantial benefit from the space program; it is an impressive list that includes higher standards of production quality in industry, accelerated use of liquid oxygen in steelmaking, development of high temperature gas-cooled and liquid-metal-cooled nuclear reactors, and many more.

The list is also useful for today's debates concerning the amount of funding appropriate for the space program. This and many other documents included in the book give an insight into the history that informs policy discussions in the present and the future.

—Marsha Freeman

AMERICAN ASTRONAUTICAL SOCIETY BOOKS ON SPACE

Prospects for Interstellar Travel, By J. H. Mauldin, 1992, 390p, Hard Cover $50, Soft Cover $27

The book reviews most of the serious published literature on interstellar travel and is a source book for professional and amateur scientists and engineers, educators and students seeking to study a problem that integrates many fields. The book also advances the literature with new ideas and findings and provides novel tools for understanding the scope of the problem. Extensive bibliography. Index.

Working in Orbit and Beyond: The Challenges for Space Medicine, Ed., D. B. Lorr, V. Garshnek, C. Cadoux, 1989, 188p, Hard Cover $22.50, Soft Cover $17.50

Topics covered are: the differences in normal physiology and adaptation to zero gravity, the special hazards of life and work in space, their countermeasures, and future challenges in space medicine.

BOOKS ON MARS

These volumes provide a blueprint for manned missions to Mars and a continued presence on the planet's surface, including what technology is required, and what kinds of precursor missions and experiments are required.

The Case for Mars III, Strategies for Exploration, Consists of two volumes. Ed., C. Stoker, 1989

Part I, General Interest and Overview, 744p, Hard Cover $37.50; Soft Cover $27.50.

Part II, Technical, 646p, Hard Cover $35; Soft Cover $25.

The Case for Mars II, Ed., C. P. McKay, 1985, Second Printing 1988, 730p, Hard Cover $30; Soft Cover $20

The Case for Mars I, Ed., P. J. Boston, 1984, Second Printing 1987, 348p, Hard Cover $45

The NASA Mars Conference, Ed. D. B. Reiber, 1988, 554p, Hard Cover $25; Soft Cover $15.

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QED Coherence in Matter, by Giuliano Preparata. River Edge, N.J.: World Scientific, 1995. Hardcover, 236 pages, $67.00.

The Quantum Theory of Motion: An Account of the de Broglie-Bohm Causal Interpretation of Quantum Mechanics, by Peter R. Holland. New York: Cambridge University Press, 1993. Paper, 598 pages.

Classical Mechanics, by Tai L. Chow. New York: John Wiley & Sons, 1995. Hardcover, 547 pages, $72.95.

Laser Experiments for Beginners, by Richard Zare and others. Sausalito, Calif.: University Science Books, 1995. Paper, 232 pages, $26.50.

Braving the Elements, by Harry B. Gray and others. Sausalito, Calif.: University Science Books, 1995. Paper, 418 pages. $29.50.

Molecular Origami, by Robert M. Hanson. Sausalito, Calif.: University Science Books, 1995. Paper, 223 pages, $22.00.

Free Atoms, Clusters, and Nanoscale Particles, by Kenneth J. Klabunde. San Diego: Academic Press, 1994. Hardcover, 311 pages, $89.00.

The Thermodynamic Exploration for High Efficiency Internal Combustion Engines, by Wayne A. Proell. Las Vegas, N.M.: Cloud Hill Press, 1993. Cloth, 531 pages, $200.

Introduction to Space Physics, edited by M.G. Kivelson and C.T. Russell. New York: Cambridge University Press, 1995. Hardcover, 568 pages.

The Solar-Terrestrial Environment, by J.K. Hargreaves. New York: Cambridge University Press, 1995. Paper, 420 pages.

Weather Cycles: Real or Imaginary? by William James Burroughs. New York: Cambridge University Press, 1992. Paper, 207 pages.

The Weather Revolution—Innovations and Imminent Breakthroughs in Accurate Forecasting, by Jack Fishman and Robert Kalish. New York: Plenum Press, 1994. Hardcover, 276 pages, $27.95.

A Field Manual for the Amateur Geologist: Tools and Activities for Exploring Our Planet, by Alan M. Cvancara. New York: John Wiley & Sons, 1995. Paper, 335 pages, $14.95.

An Introduction to Cosmochemistry, by Charles R. Cowley. New York: Cambridge University Press, 1995. Paper, 490 pages.

The Rainbow and the Worm: The Physics of Organisms, by Mae-Wan Ho. River Edge, N.J.: World Scientific, 1993. Paper, 202 pages, $21.00.

Advances in Electromagnetic Fields in Living Systems, Volume 1, edited by James C. Lin. New York: Plenum Press, 1994. Hardcover, 196 pages.

HIV and the Pathogenesis of AIDS, by Jay A. Levy. Washington: ASM (American Society of Microbiology) Press, 1994. Paper, 359 pages.

Dark Sun: The Making of the Hydrogen Bomb, by Richard Rhodes. New York: Simon & Schuster, 1995. Hardcover, 731 pages, $32.50.

Genius in the Shadows: A Biography of Leo Szilard, The Man Behind the Bomb, by William Lanouette with Bela Silard. Chicago: University of Chicago Press, 1994. Paper, 603 pages, $18.95.

Powering Apollo: James E. Webb of NASA, by W. Henry Lambright. Baltimore: Johns Hopkins University Press, 1995. Hardcover, 271 pages, $35.95.

Between Copernicus and Galileo: Christoph Clavius and the Collapse of Ptolemaic Cosmology, by James M. Lattis. Chicago: University of Chicago Press, 1995. Paper, 293 pages, $22.50.

Galileo for Copernicanism and for the Church, by Annibale Fantoli. Notre Dame, Ind.: University of Notre Dame Press, 1994. Paper, 352 pages, $21.95.

The Scientific Revolution: A Historiographical Inquiry, by H. Floris Cohen. Chicago: University of Chicago Press, 1994. Paper, 662 pages.

The New Ecological Order, By Luc Ferry. Chicago: University of Chicago Press, 1995. Paper, 188 pages, $14.95.

But Is It True? A Citizen's Guide to Environmental Health and Safety Issues, by Aaron Wildavsky. Cambridge: Harvard University Press, 1995. Hardcover, 574 pages, $35.00.

Reinventing Darwin—The Great Debate at the High Table of Evolutionary Theory, by Niles Eldredge. New York: John Wiley & Sons, 1995. Hardcover, 244 pages, $27.95.

Hydrocarbon Chemistry, by George A. Olah and Arpad Molnar. New York: John Wiley & Sons, 1995. Hardcover, 632 pages, $69.95.

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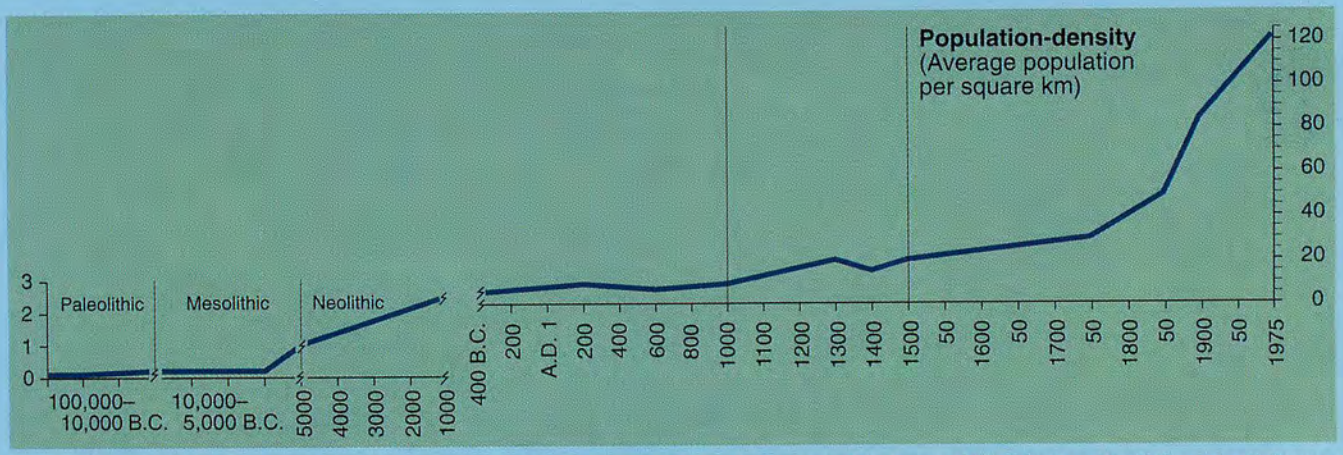
In This Issue:

KENNETH ARROW RUNS OUT OF IDEAS, BUT NOT WORDS

An exposé of typical environmentalist mumbo-jumbo, packaged as "science," in a policy article written by Nobel Laureate Kenneth Arrow and others for *Science* magazine. Economist Lyndon LaRouche shows how this fraud is used to justify reductions in population and science capability, and he specifies how economic activity must actually be measured.



Economic growth as a function of man's increasing mastery over nature can be measured in terms of the increase in relative potential population density and is a phenomenon unique to man. Shown here is the estimated population density of the European population from 100,000 B.C. to 1975. Note the accelerated increase over the last 600 years.

COLD FUSION: SLOW, STEADY PROGRESS AND SOME FAST TALK

Cold fusion remains a hot topic among its critics and boosters. Editor Carol White gives a more sober account of where the research stands in an exclusive report on the Fifth International Cold Fusion Conference, held in Monaco in April.

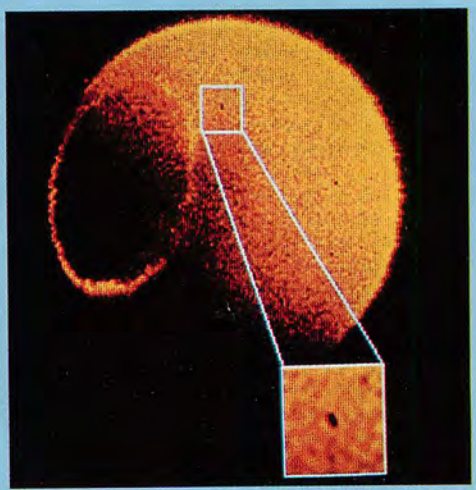
Carol White and cold fusion pioneer Martin Fleischmann discuss an experiment.

RED SPRITES, BLUE JETS, AND ICEBALLS

What is really going on up there? As more advanced instruments open new windows on the atmosphere and provide new data, scientists are revising some old assumptions to take into account unexpected complexities. In the Special Report, Mark Wilsey looks at red sprites and blue jets, the upper atmospheric electrical activity that accompanies lightning, and Jim Olson tells the story of Dr. Louis Frank and his hypothesis that thousands of 100-ton iceball comets hit the Earth every year. Other solar and geophysical phenomena will be explored in future issues.

Geophysical Institute, University of Alaska, Fairbanks

The first true color image of a sprite, observed over a thunderstorm in the Midwest in July 1994. The top of the sprite is higher than 85 km (280,000 feet), while the blue, root-like tendrils below it are as low as 60 km. The white-blue area beneath the sprite is an overexposure of normal lightning at the cloud top.



Dr. L.A. Frank, University of Iowa

An ultraviolet image from Dynamic Explorer I—showing Earth's dayglow and auroral halo over the magnetic pole. Inset is an enlarged area showing one of the dark spots that Frank argues are the vapor remnants of ice comets.