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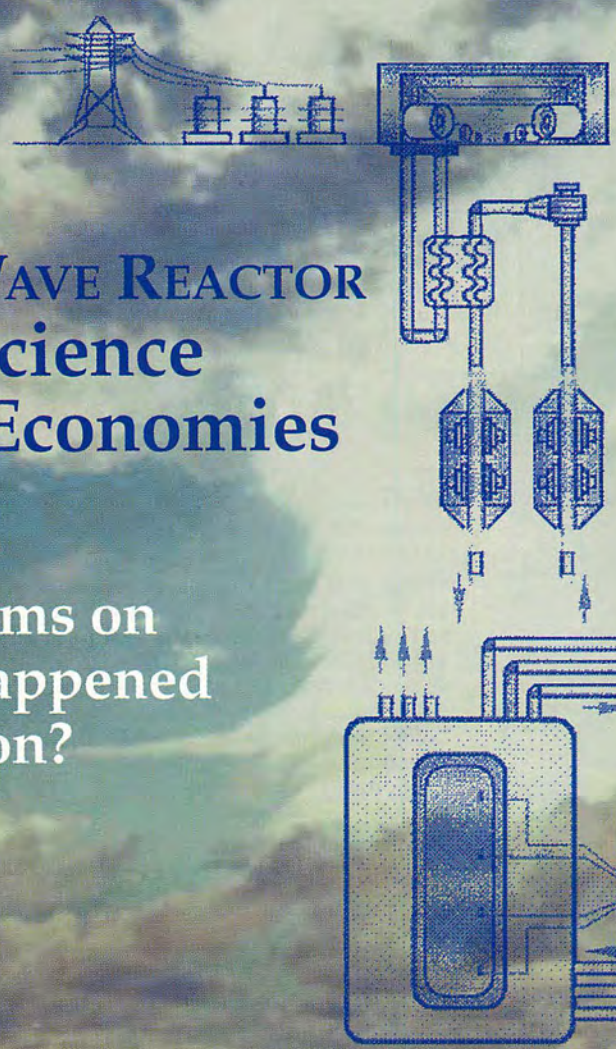

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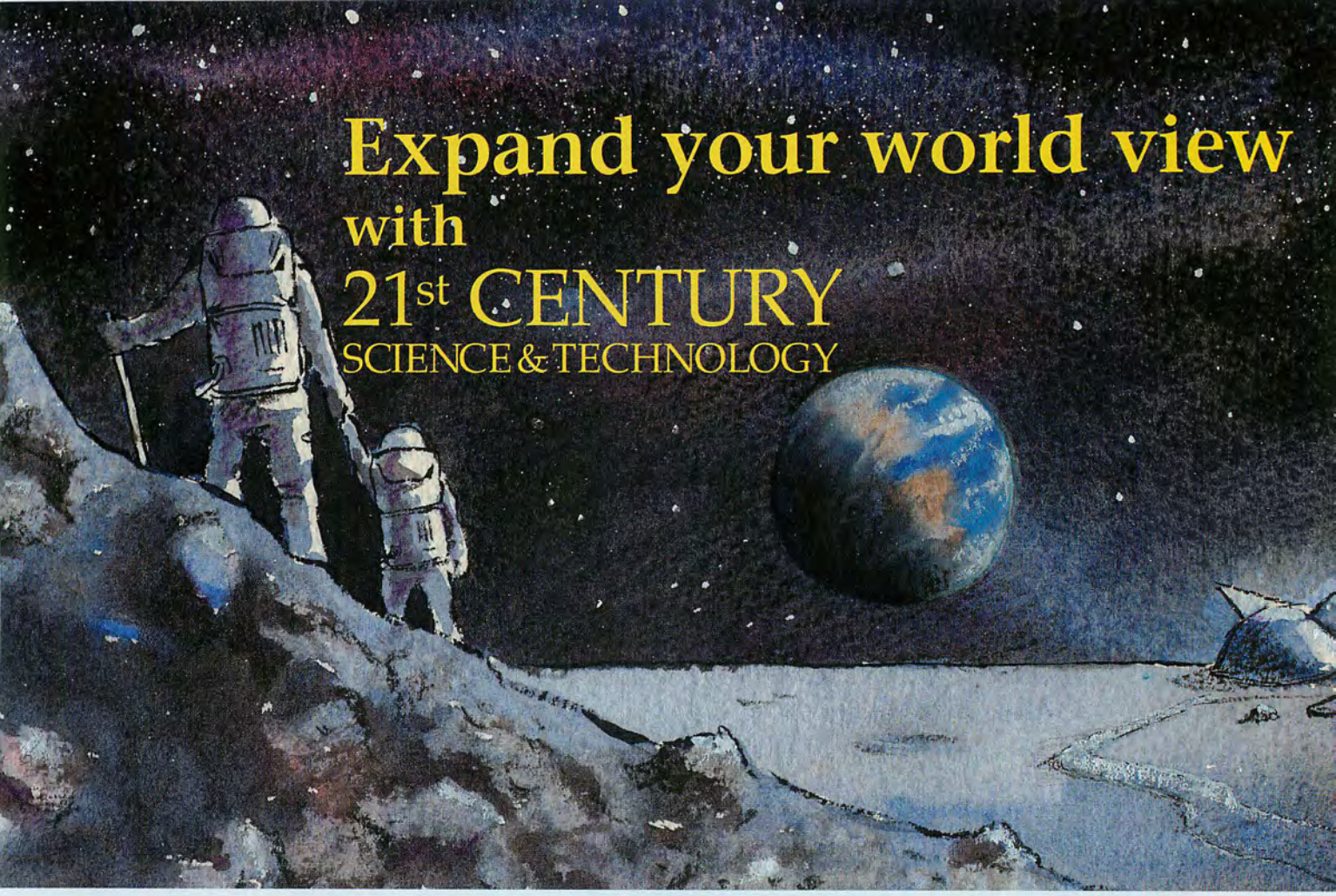

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21st CENTURY SCIENCE & TECHNOLOGY

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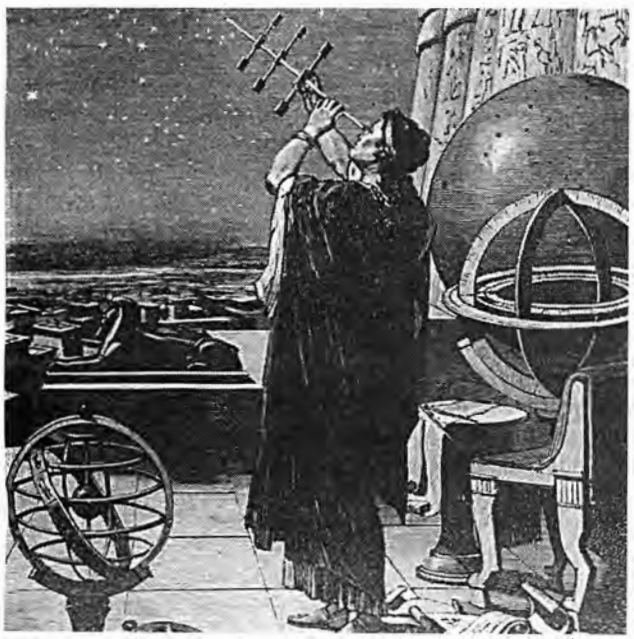
Features



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Eratosthenes' experiment to calculate the circumference of the Earth was a revolution in how man thought. Caroline Hartmann traces the history of geodesy, from Eratosthenes to the 19th century (p. 48).

News

Departments

On the cover: Schematic of the bum-wave fission reactor, courtesy of Lawrence Livermore National Laboratory; in the background, an atomic bomb explosion, courtesy of Los Alamos National Laboratory. Cover design by Rosemary Moak

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The Eurasian Land-Bridge Is Changing the Political Climate

If not for an almost total blackout in the U.S. national media, more readers might already know of the vast climate change—political climate, that is—as China, Russia, Japan, and other nations begin collaborating to make the Eurasian Land-Bridge project a reality. The recent diplomacy of Chinese President Jiang Zemin, in visits to Russia and Japan, unleashed the potential to reverse the deindustrialization landslide and its accompanying demoralization, as well as the ongoing financial collapse. Jiang Zemin called for "a new technological revolution," as you can read in his speech (p. 23) to scientists and engineers at the science city of Novosibirsk in Russia, Nov. 24, and his Land-Bridge agreements with Russia and Japan are an opening salvo to make that revolution happen.

How can we make the United States a part of this revolution?

The urgency of this task, and the difficulties, were all too evident at the winter meeting of the American Nuclear Society in Washington, D.C., Nov. 15-19. At one session, some of the nation's top nuclear officials, including a former director of a national laboratory, admitted their utter failure in the political arena and in educating the public. Technically, we've accomplished wonders in nuclear science in the past 50 years, but in all other ways we've failed, one person stated. "We can't move nuclear technology forward in this political climate," was the general lament. One industry engineer, who has worked on fast reactor technology for most of his career, said sadly, "I'd like to see at least a demonstration fast reactor built in my lifetime."

It was a baleful testimony to the decline of America's once proud technology leadership, enough to make one cry. Yet, every one of these nuclear leaders *could* change the political climate—and their self-indulgent impotence. How? By joining with the forces behind the Eurasian Land-Bridge, who are carrying on with the spirit and philosophy that built the American nation, and steered its great projects (like the Manhattan Project) to success.

Jiang Zemin's Initiatives

Just a few days after the ANS meeting, Jiang Zemin, an engineer, was in Novosibirsk, speaking to scientists and engineers there about the importance of science and creativity in moving civilization forward. He also met with Russian Prime Minister Primakov, confirming cooperative agreements to build the 11,000-mile Eurasian Land-Bridge, from Lianyungang, on China's east coast, to the European port of Rotterdam. In this project, Russia's tremendous scientific and technological potential, which is concentrated in the "closed cities" of the military-scientific-industrial complex (and now languishing in the collapse of the Russian economy), will be invaluable.

From Russia, Jiang Zemin went to Japan, where he met with Prime Minister Obuchi, and signed an agreement to collaborate on the Land-Bridge. As stated in their Joint Press Announcement Nov. 26: "Both sides believe that the Eurasian Land-Bridge Project, which spans from East Asia across Central Asia to Europe, has a positive significance for the peace and stability of the entire Eurasian continent. Both

MAIN ROUTES AND SELECTED SECONDARY ROUTES OF THE EURASIAN LAND-BRIDGE

sides, with the recognition of the importance of enhancing the transportation and distribution infrastructure from East Asia to Central Asia, confirmed that they will promote cooperation in this area."

The Japanese daily *Nihon Keizai Shimbun* reported Nov. 26 that: "the Japanese and Chinese governments have agreed to cooperate in construction of a Eurasian Land-Bridge . . . to include railways, roads, and fiber-optic networks running through 30 countries; the goal is to develop a major economic artery spanning the Eurasian landmass. . . . With the zone extending through the vast, untapped energy resources of Central Asia, it is likely that major Russian and U.S. companies will take an interest in the project. China will set up a Sino-Japanese regional development center, and Japan will assign specialists to it to draft plans for railway and road networks and shipments of energy resources. Japan will host a public-private seminar on means of materializing the project. China wants to build a highway, pipeline, and optical-fiber network alongside a planned new Eurasian rail system."

The LaRouche Connection

The concept behind the Eurasian Land-Bridge originated with economist and statesman Lyndon H. LaRouche, reviving and expanding the 19th century American System methods that industrialized the United States, and spread through Russia, Japan, and China via the Lincoln administration policies. LaRouche's writings on the Land-Bridge concept, and those of his associates, including a book-length technical report published by *Executive Intelligence Review,* have circulated widely.

In October, a Schiller Institute delegation, led by Helga Zepp-LaRouche, went to China to participate in a series of conferences on the Land-Bridge, hosted by the Chinese Academy of Sciences and local governments in four cities. The speeches from that conference, "Asia-Europe Economic and Trade Relations in the 21st Century and the Second Eurasian Bridge," are available from *Executive Intelligence Review* in the Dec. 4 and Dec. 11 issues.

21st Century covered the Land-Bridge technologies in the Winter 1996-1997 and Spring 1997 issues. This issue of *21st Century* reports briefly (p. 24) on Zepp-LaRouche's intervention in Mexico, with the Land-Bridge concept, and on a similar infrastructure project to integrate the South American continent. As she told her Mexican audiences, the growing resistance in Asia to the policies of the international monetary institutions, provides us with a unique opportunity.

The U.S. nuclear community, and scientists, industrialists, and others concerned with turning around the present economic, cultural, and scientific collapse, have to grab this opportunity, and break with the ideological constraints imposed by the New Age and its media. The key to the Eurasian Land-Bridge, as stressed by Jiang Zemin, and by LaRouche, is the technological revolution required in order to meet the demands of economic survival and development for all of the peoples of Eurasia.

Like the scientific capabilities locked up in the closed science cities of Russia, the capabilities of U.S. advanced science and technology, in the national laboratories and in industry, have to be unlocked. Then the United States can join with the Eurasian nations in making the Land-Bridge the engine of a global economic renaissance—in our lifetimes.

Letters

Yes, Virginia, There Is a Dr. Todtkopf

We reprint here the correspondence between 21st Century *and a senior biophysicist concerning the articles on the work of Alexander Gurwitsch ("Alexander Gurwitsch and the Concept of the Biological Field"), which appeared in the Summer and Fall 1998 issues of* 21st Century. *This correspondence is useful because it underlines some of the basic issues in Gurwitsch's work, and it makes it clear that such characters as the Dr. Todtkopf and Prof. Lebensfroh, featured in the dialogue by Jonathan Tennenbaum (p. 28), are not only fictional.*

The name of the biophysicist has been withheld, upon his request.

To the Editor:

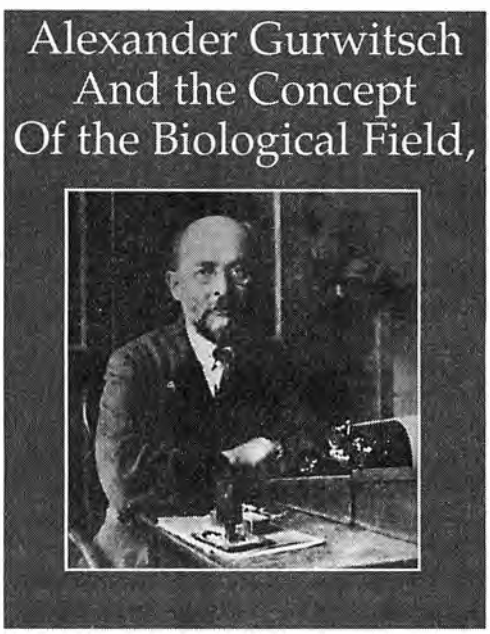
Thank you for sending me the Summer [1998] issue. I read the issue with interest but, from what I knew, the articles on Gurwitsch were way off base. The late Alexander Hollaender travelled to the Soviet Union under the auspice of the Rockefeller Foundation to work in Gurwitsch's laboratory. After a three-month stay there, he returned to the United States and continued working on the properties of mitogenetic radiation in collaboration with a number of other individuals. Hollaender had an active interest in the field but finally concluded that most of the results were not only inconclusive, but inconsistent.

He and W.D. Claus wrote a review on mitogenetic radiation entitled, "An Experimental Study of the Problem of Mitogenetic Radiation" that appeared in Bulletin 100 of the National Research Council, published by the National Academy of Sciences in 1937. The review concluded that mitogenetic radiation could not be demonstrated. Hollaender was a preeminent photobiologist with extensive training in physical chemistry. He was quantitative in his analyses.

Thus, to the best of my knowledge, mitogenetic radiation has no foundation in physical reality as we know it.

Associate Editor Colin Lowry Replies

[The editor] has asked me to respond to your letter concerning Alexander Gurwitsch, and to bring you up to date on photon emission from living cells. A lot has happened since 1937, and, in fact, photon emission has been found to be a property of all living cells, not just in mitosis. The study by Hollaender you cite is useful as an example of how science



that does not conform to the politically correct ideas of the time is controlled and buried. At the time, Hollaender was already aware that the mitogenetic radiation experiments had been successfully repeated by researchers in the Siemens Company laboratory in the 1930s in Germany.

Dr. Fritz Albert Popp and my colleague, Dr. Jonathan Tennenbaum, visited with Dr. Hollaender in the early 1980s in New York. Dr. Popp was working on photon emission from living cells, and had come to see Hollaender to tell him that he was now measuring Gurwitsch's mitogenetic radiation. Dr. Hollaender told him that he believed that Gurwitsch had found something, and that he had found evidence of photon emission, but that he was sent to do a hatchet job on Gurwitsch's work by the Rockefeller Foundation. The report in the National Academy of Sciences that was published was designed to crush any interest in this field in the United States, and it was quite successful for many decades, although in Europe the research continued slowly.

Gurwitsch's original experiments have recently been repeated in Russia using modern equipment, and there has been an active but small group of researchers involved in this area since the 1970s. The first quantitative analyses demonstrating biophoton emission were done in the 1950s.

It is worth pointing out, that the biophoton emission is only one part of Gurwitsch's biological field theory. He warns that attempts to reduce the cell to currently known physics, can never explain the living state. The other questions he raises in embryology, in mitosis, and differentiation, have not been studied adequately since his death, in the context of the electromagnetic organization of living processes. The bias against such an approach comes from the reductionist ideologies that dominate the minds of most scientists today.

Last month, there was an international conference of the researchers working on biophotonics and related questions that took place in Germany. I received a report from this conference that biophoton emission from respiratory bursts from granulocytes and other immune cells was shown to trigger activation of immune cells in a neighboring cell culture.

I am sending you a copy of the 1988 review from *Experentia* on the subject of Gurwitsch and biophoton emission, which was coordinated by Dr. Fritz Albert Popp, one of the leading scientists working on biophoton emission today. . . . I will also supply you with other references at the end of this letter.

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F.A. Popp, W. Nagl, K.H. Li, et al., 1984. "Biophoton Emission: New Evidence for Coherence and DNA as Source," *Cell Biophysics*, Vol. 6, p. 33.

L.V. Beloussov and F.A. Popp, 1995. *Biophotonics—The Non-Equilibrial and Coherent Systems in Biology, Biophysics, and Biotechnology*. Moscow: Bioinform Services. Neuss Germany: International Institute of Biophysics (in English).

F.A., Popp, K.H. Li, and Q. Gu, 1992. *Recent Advances in Biophoton Research and its Applications*. Singapore, New York: World Scientific.

The Biophysicist Replies —Again

To the Editor:

Thank you for sending me the Fall issue of *21st Century*. I read carefully the articles on Gurwitsch and his apparent data and theories.

I still have seen no convincing data indicating that there is such a thing as mitogenetic radiation. The notions about "fields" is purely speculative since no experiments are yet available to confirm any predictions of these notions.

In the experimental world in which I live, there are many data on the genes involved in changes in development and how the recent rapid advances in molecular biology are leading to these understandings. After all, an organism begins from a single cell. The origin of these presumptive fields must reside in that cell but there are no data indicating that individual cells send out radiations to affect other nearby cells.

Sorry, I don't believe any of it.

Gurwitsch Appreciated

To the Editor:

Having just completed a first reading of the article in the Summer 1998 issue, titled "Alexander Gurwitsch and the Concept of the Biological Field," I feel compelled to express both a profound gratitude for your bringing to my attention such an enormously significant body of work, and an equally enthusiastic anticipation of your fall issue with the second part of the article.

In the meantime, I would be most grateful if you could tell me whether there are English translations currently available of Prof. Gurwitsch's *Histological Foundations of Biology* (1930), or *The Theory of the Biological Field* (1944). If not, might 21st Century Science be considering sponsoring such translations? I believe that this would be an invaluable service.

Mark Douglas Reiners
Los Angeles, Calif.

The Editor Replies

Unfortunately, there are no English translations of the original papers of Alexander Gurwitsch. The originals are published in Russian, German, or French. This would be a worthwhile project to be funded, and *21st Century* would welcome assistance in getting this project going.

Thinking about How A Foucault Pendulum Works

To the Editor:

I did a double take reading the last issue of *21st Century,* where it was said that Foucault's pendulum made a complete 360 degree rotation in 24 hours, except in Richmond, Virginia, where it takes 29 hours and 27 minutes [illustration on p. 27 and back cover, in "Should the Laws of Gravitation Be Reconsidered?" by Maurice Allais]. I knew this could not be true—even in the heyday of the Confederacy—but I could not remember the formula I had duly memorized so many years ago.

Science Museum of Virginia

However, by thought experiment, you can see that at the poles, the pendulum would appear to go around in 24 hours, as the Earth rotates under it, since the zenith and the pole coincide; that is, the angle between the line of sight going to the pole, and the string or cable of the pendulum, going "straight up," is zero. (Here also, a sundial, with its gnomon pointing to the zenith/pole, would slice the day up into neat 15 degrees per hour.)

Also by thought experiment, at the equator, the angle between the line of sight to the pole, would now coincide with the horizon, and the pendulum string going up toward the zenith, would be at 90 degrees. Thus, the Earth would appear not to rotate at all relative, to the plane in which the pendulum swings, because the pendulum is swinging parallel to the Earth's axis. .

So, you might guess that the trigonometric function you're looking for is a sine, since the sine of 90 degrees is 1, and the sine of 0 degrees is 0.

It would not be any fun to give the whole answer here. The reader should work the rest out for himself: using diagrams, models of the Earth, simple trigonometric relations, picking a spot with a specific latitude, drawing the plane of the horizon there, and arriving at the time for a pendulum to turn 360 degrees, which is equal to 24 hours divided by the sine of the angle of the latitude.

This experiment should also make us pause, before we too readily agree that a gravitational field is indistinguishable from a field caused by accelerated motion. In the often-cited thought-experiment, it is alleged that if you were in a huge windowless room, there would be no experiment you could do, that would tell you whether you were in a room on a planet whose gravity was causing objects to fall at a specific acceleration, or if you were being pulled by a rocket ship at that acceleration. What if you took a pendulum around to learn a couple of things!

Rick Sanders
Leesburg, Virginia

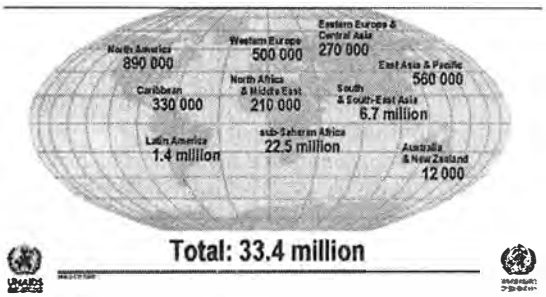
The Plain Truth

To the Editor

I admire *21st Century* scientists and editors, for the plain truth, and that is to explain the truth without coverup and compromise. But the American people are physically present, mentally absent, sleeping like the inhabitants of ancient caves.

Thank you so much for educating us.

Johannes Zemichael
Scott, La.



The latest U.N. AIDS epidemic update estimates that 33.4 million people now have AIDS, and that in the next few years, AIDS will turn much of Africa into a graveyard.

U.N. AIDS PROGRAM REPORT SHOWS AFRICAN HOLOCAUST

The United Nations AIDS Program issued its updated 1998 report Dec. 1, documenting a 10 percent increase in HIV infections worldwide over the past year, and the utter devastation of the African population. Since the beginning of the epidemic in the late 1970s, some 34 million Africans have been infected, and 12 million have died, one-quarter of the dead being children. In 1998, about 70 percent of new HIV infections in the world occurred in sub-Saharan Africa. In the nine countries of southern Africa, HIV prevalence in the adult population is 10 percent or higher. In Botswana, Namibia, Swaziland, and Zimbabwe, between 20 percent and 26 percent of the adult population is infected with HIV. With infection rates at levels this high, these countries will have lost almost an entire generation to the AIDS epidemic by 2010.

Also Dec. 1, President Clinton presented a series of new initiatives to increase funding for AIDS vaccine research, and provide emergency funds to help care for children who have been orphaned by the epidemic in Africa and elsewhere.

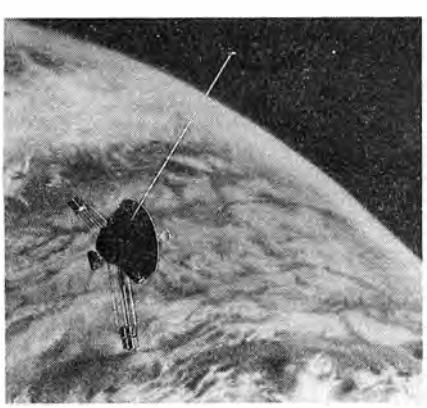
TUBERCULOSIS EPIDEMIC SWEEPING ACROSS ASIA

The World Health Organization (WHO) reports that India, China, Bangladesh, Pakistan, Indonesia, and the Philippines alone have 56 percent of the 8 million reported tuberculosis cases in the world, and that 3 million of those infected are expected to die. WHO Director-General Gro Harlem Brundtland told a recent international conference in Bangkok, "A disease that many of us believed would disappear in our lifetime is killing more people today than at any time in our history."

U.S. DOE RECEIVES 524 PROPOSALS FOR NUCLEAR R&D

The Department of Energy division in charge of the Administration's Nuclear Energy Research Initiative (NERI) has received 524 proposals from researchers in industry, universities, and national laboratories to work on new ideas in producing and using nuclear power, according to a report in the Dec. 11 *Science* magazine. The proposals include the design of compact, easily deployable reactors for developing nations.

The NERI program had been proposed by the Department of Energy a year ago, but was not funded by the Congress. The fiscal year 1999 budget, however, includes $19 million to start the research programs, although the White House had requested $24 million. In a report released a year ago, the President's science and technology advisory panel said that $50 million per year was needed in nuclear research and development, increasing annually to $100 million by 2003, lest the nation entirely lose the nuclear option in energy production. Of major concern is the fact that in the 1990s, enrollment in nuclear engineering and related programs has declined by 10 percent per year, and that graduate programs offered in nuclear fields have fallen by 30 percent since 1975, and now stand at 35.



NASA

Is the sky falling? Or is another explanation required for why satellites like Pioneer 10 and 11 are experiencing anomalous gravitational acceleration. Here, an artist's concept of Pioneer over Jupiter's surface.

DATA FROM SATELLITES INDICATE 'THE SKY IS FALLING'

The Oct. 5 issue of *Physical Review Letters* reports that radio telemetry data from all deep-space satellites indicate an anomalous gravitational acceleration. The satellites Pioneer 10 and 11, Galileo, and Ulysses are all experiencing a slightly greater apparent pull by the Sun than that projected by the current theories of gravity, which are generally based on Newton's Theory of Universal Gravitation. These data could confirm the work of Dr. Benny Soldano, physicist and member of the science advisory board of *21st Century*, who has recently published a book titled *Non-Equivalence: A Key to Unity*. The book sums up almost five decades of Soldano's work on his theory of the non-equivalence of inertial and gravitational mass—a hypothesis contrary to that of Newton.

CHINESE PRESIDENT PUTS EURASIAN LAND-BRIDGE ON WORLD AGENDA

In November summit meetings with Russian Prime Minister Yevgeni Primakov and Japanese Prime Minister Keizo Obuchi, Chinese President Jiang Zemin concluded agreements on the Eurasian Land-Bridge project of transportation and agro-industrial development corridors, stretching 11,000 km from the east coast of China to the European port of Rotterdam. The U.S. major media chose to black out news of this major world development.

As described by one Japanese daily, "The Japanese and Chinese governments have agreed to cooperate in construction of a Eurasian Land-Bridge . . . to include railways, roads, and fiber-optic networks running through 30 countries; the goal is to develop a major economic artery spanning the Eurasian landmass. . . . With the zone extending through the vast, untapped energy resources of Central Asia, it is likely that major Russian and U.S. companies will take an interest in the project. China will set up a Sino-Japanese regional development center, and Japan will assign specialists to it to draft plans for railway and road networks and shipments of energy resources. . . ."

The proposal for the Eurasian Land-Bridge was first put forward by economist Lyndon LaRouche.

Stuart Lewis/EIRNS

Chinese President Jiang Zemin reached agreements on the Eurasian Land-Bridge with both Russia and Japan in November. Here, Jiang at his October 1997 meeting with President Clinton.

ADAMOV OUTLINES RUSSIAN EXPORTS OF NUCLEAR PLANTS

In a press conference Dec. 8 in Moscow, Yevgeny Adamov, Russia's Minister for Atomic Energy, reported on his recent trips abroad to firm up export business for the nation's nuclear energy industry. Although Iran is an oil-rich country, he said, "the strategically minded leadership of that country is looking 30 years ahead and more," and Russia has received an offer to build three nuclear units in Iran. As for concerns with proliferation, Adamov said that Russia should be, and is, more concerned about weapons proliferation in Iran than the United States is, because America is an ocean away and Russia is right next door.

Adamov said Russia is also working on the contract for a new power plant in China, and has signed a contract with India for design of a plant, which will be completed in the first half of 1999. The Indian nuclear regulatory bodies will then make a decision on building the plant. As for Russia's domestic nuclear situation, Adamov stated, "We intend to dramatically cut the number of facilities in which we invest, in order to concentrate our investments in facilities which are nearing completion and can be quickly put into operation, and bring returns."

FOR GREENS, 'SMALL IS BEAUTIFUL, BIG IS SUBSIDIZED'

Several green groups, including Friends of the Earth, the Gaia Foundation, and the Club of Rome have recently attacked the current market system and globalization. Why? According to the director of the British-based International Society for Ecology and Culture (ISEC), Helene Norberg-Hodge, it's because of the "demonstrable, mad investment in infrastructure" taking place around the world. When asked, does this include the Eurasian Land-Bridge project, Norberg-Hodge replied, "Absolutely!" She then attacked the building of bridges between Sweden, Denmark, and Norway; plans for linking up Spain and North Africa; the already completed Channel Tunnel between Britain and France; and European plans for high-speed rail. Norberg-Hodge says she's the "driving force" behind the launching of the International Forum on Globalization.

The ISEC produced a report titled "Small is Beautiful, Big is Subsidized," which attacks transport infrastructure projects, including the 19th century building of the continental railway system in the United States, because it helped "subdue and civilize the untamed wilderness." The report bemoans the fact that the East and West coasts of the United States were linked by rail. "Many people today believe things would be far better if the nation were divided into much smaller entities," the report says.

Rolling back progress: a green view of the U.S. future.

Can the Greens Destroy Nature?

by James Dunn, Ph.D.

For the decades that America's technological society has been under attack by its environmental leadership, a major fact has been hidden: Only advanced technological nations have ever reversed the degradation of the natural environment that accompanies human occupation. Americans need to understand the truth and implications of this statement and how they have been led to believe something else. We can then better evaluate the irrationalities of the environmental movement and its dangerous counter-productivity.

Some Environmental Paradoxes

I will summarize technology's environmental virtues as related to nature by discussing some apparent paradoxes. In each case, the accuracy of the paradox is verified by summarizing facts that have been hidden from the public.

Paradox 1. Technologists are far more beneficial for the natural environment than are their environmental critics.

To see why this is true, let's analyze the major positive environmental changes that have occurred in America during the past 150 years.

Forests and trees. Major increases in the tree population have taken place in the eastern two-thirds of America. These changes started in the Midwest with its settling in the early to mid-1800s; in the eastern third, America's new coat of green started in the 1920s. The increase of tree cover in former prairie areas was the inevitable result of people *using* the land for agriculture. The increase of tree cover in the eastern states was the inevitable result of people *no longer using* the land for agriculture, and moving to cities. The changes in the prairie states contributed to the changes in the East. Nature was the winner in both areas.

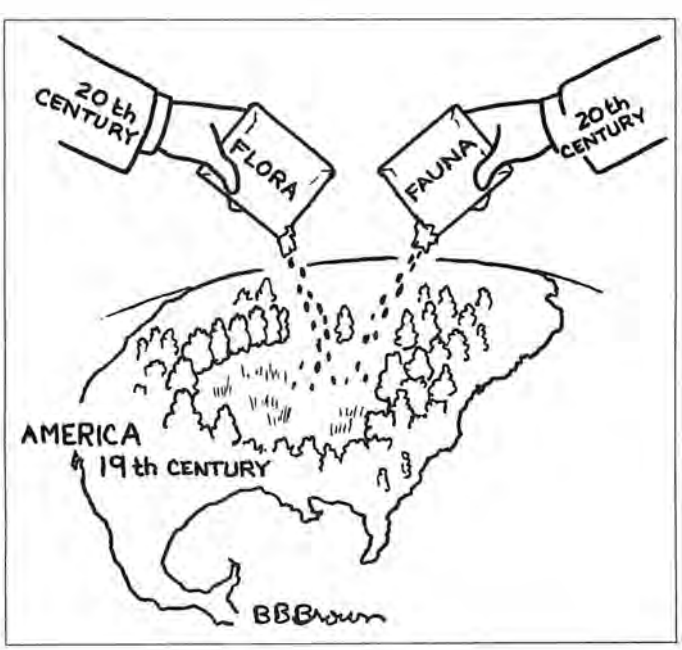
When the first settlers came to the Midwest, the area was a monotonous grassland created largely by the repeated burning of vegetation by the Indians over thousands of years (Stewart 1956). Burning expanded the prairies, and thus the bison herds, but it denuded vast areas of trees and brush. In this hostile environment, farmers had to use dried bison dung, crop residues, and grasses for cooking and heating fires.

Quickly the early farmers planted trees around their farm buildings, in towns, along fence lines and in wood lots. In addition, states peripheral to the central prairie land, like Tennessee, Kentucky, Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota grew new forests, naturally, by afforestation on former prairie that was not tilled (Stewart, *op. cit.*).

Also, cottonwoods, willows, and associated understory growth returned by afforestation along the major river systems west of the Mississippi River (Dusek et al. 1989 and Curtis 1998).

In the East, generation of new tree cover started somewhat later. In the early 1800s, wood was the only source of energy. Large areas around cities and iron furnaces were stripped of trees for energy. As we developed coal resources and rail transportation, coal, and later oil, replaced wood. Electrical power generated by coal, oil, and water completed the change from wood. Although some people still use wood for energy, most can get along without it.

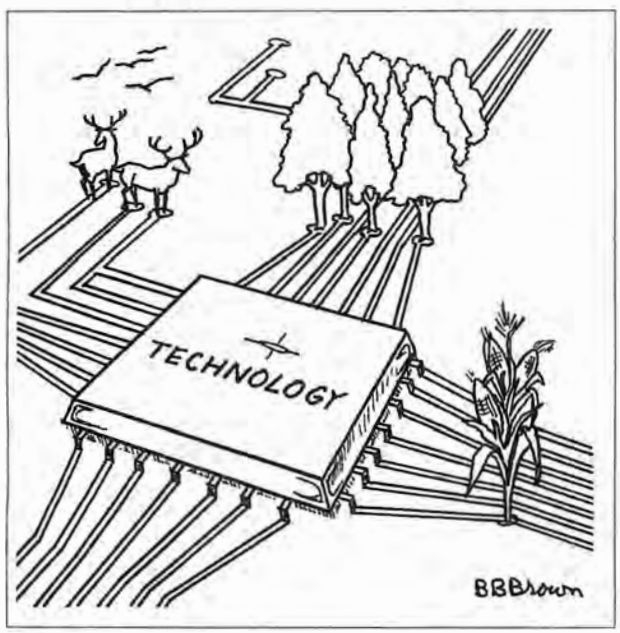
Just as important, new agricultural technology, such as agricultural chemicals and tractors, allowed us to retire marginal croplands and pasture lands. The major release of agricultural land in the East started in the 1920s, but the expansion of dry-land farm areas in the Great Plains (1909-1920), and the increase in irrigated land in the West through the 1970s (U.S. Department of Agriculture 1976), more than counterbalanced the land released in the East. Hence America's total agricultural land did not decrease until about 1960.



The agricultural land released from 1960 through 1996 alone is 208.9 million acres (Wright 1997), more than 8 million acres per year. The U.S. Department of Agriculture (1989, p. 141) predicts that America will release up to 160 million more acres by 2030. However, major worldwide changes may

make this estimate too low. Kilman (1998) describes current major failures of farms in the northern plains states because of a combination of deregulation and high agricultural productivity, both in America and in foreign countries. This could be partly the result of the predicted "carbon dioxide bonus" as the world's crops respond to higher carbon dioxide levels in the atmosphere. Carbon dioxide, of course, is plant food.

Our use of mineral-based construction products such as brick, steel, glass, cement, and stone for large buildings and other structures further decreased demand for wood. And people able to live and work in tall buildings require far less land than people in low buildings. Using less land takes pressure off forests. Further, our use of wood preservatives allows wood to last longer. According to Barrons (1981, p. 60), without wood preservatives, a forest twice the size of New England would be needed just to replace rotted wood in buildings and fences on a sustained basis. The total decrease in demand for wood for construction allows us to fill all of our need for construction wood with but 5 percent of our forest (Sedjo 1995).



Since 1920, America has added some 140 million acres of new forest, the equivalent of the land area of Vermont, Massachusetts, Rhode Island, New York, Pennsylvania, New Jersey, Maryland, Virginia, and North Carolina (Dunn and Kinney 1996, pp. 17, 37). Some 75 million acres of new mesquite also returned to the Panhandle region of Oklahoma, southward into Texas (Stewart, *op. cit.*).

In addition, billions of trees have been planted throughout America. New York's Saratoga nursery alone has sold more than 2 billion trees since the early 1900s. Currently, it would be difficult to find a vista from the Atlantic Ocean to the Rocky Mountain front, from the Canadian border to the Gulf Coast, where new trees or woods are not visible.

Wildlife. Wildlife that require trees have proliferated. Wildlife in large areas of the eastern two-thirds of our "lower 48" are both more abundant and more diverse than in 1492. The mix of suburbs, tilled fields, land reverting to new woods, and old forests of the East favors a diverse and plentiful fauna. The best measured change is the white-tailed deer population. Recent record deer harvests throughout the East reflect record total deer populations (Dunn and Kinney 1996, 62-67).

Because the East in 1492 was largely covered with old forest, which will not support a high deer population, the white-tailed deer are probably more abundant now than ever before. Other wildlife populations have similarly increased. Turkeys, coyotes, wood birds in general, and squirrels have all proliferated. Pyne and McCoy (1998) from more recent data, conclude that most eastern states will see record or near-record harvests of deer this year; so the trend continues. Turkeys, which share the deer habitat, will also probably be at record levels for 1998.

In the central United States, the white-tailed deer population is also setting new records, but for somewhat different reasons. The new woods in states adjacent to former grasslands, of course, bear most of the responsibility. But major river systems such as the North Platte, Missouri, Yellowstone, and Snake have all seen a return of cottonwood, willow, and related understory vegetation, because the prairies are no longer burned. Dushek, et al. (1989) and Curtis (1998) describe the process in detail for the Yellowstone River in Montana. With the new cover and understory browse added to crops in nearby fields, white-tailed deer are abundant.

Along with deer, birds have returned. Welsch (1992) describes the conditions in Nebraska when the white man first arrived: "And there were few birds: no cardinals, no robins, no orioles, no owls, no thrushes, no siskins, no goldfinches, or wood ducks." Now, the Audubon Society's bird books tell us that all of these birds are present throughout the area.

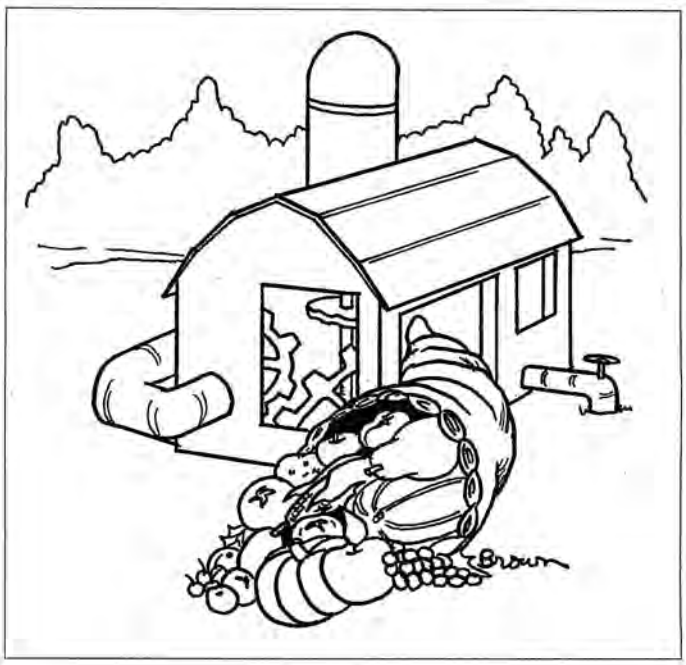
Finally, another largely ignored wildlife conservation benefit is the several million new ponds in America. The man-made ponds are breeding and stopover sites for water birds and attract other wildlife. In addition, many are stocked with fish.

Biodiversity. Floral biodiversity has increased throughout America because much exotic vegetation has been imported from other areas. For example, Americans have planted Australian eucalyptus, Russian olive, Chinese chestnut, Austrian and Scotch pines, and Norway spruce through much of America. Most of the 16 trees and shrubs offered for sale by New York's 1998 Rensselaer County Soil and Water Conservation District are not native to New York state.

Foreign imports comprise about 15 percent of the species described in *The Audubon Society Field Guide to North*

American Trees, Eastern Region (Little 1980). In addition, many of our flowers, shrubs, and food trees and plants are imports, a fact acknowledged by Al Gore (1992, pp. 734-735).

Finally, our botanical technologists continuously create new hybrids of food and decorative plants further increasing floral biodiversity. A modern seed catalogue includes about 10 percent new hybrids annually in its listings. Floral diversity has never been greater in America.



Faunal biodiversity has expanded in many areas of America. I have already discussed the return of white-tailed deer in much of the Midwest. Similarly, the increased diversity of birds in the Midwest is indisputable. The dominant, relatively simple faunal complex that the Indians created has been replaced by a far more diverse fauna. Also, through much of the eastern states, faunal abundance has never been greater.

Erosion. Since 1910, per acre agricultural production in America has increased about 5.59 times faster than the population has grown (Dunn and Kinney 1996, pp. 18, 25). Because unneeded farm land now has permanent natural cover, soil erosion has decreased. In fact, the rate of new soil generation on such land far exceeds the erosion rate. Additionally, because the quantity of tilled land is reduced, and the land that is used is the flattest, erosion of tilled land is decreasing.

The greatly decreased erosion is described by the U.S. Department of Agriculture (1989), which anticipates a 57 percent further reduction in erosion of agricultural land by 2000. The unanticipated (in 1989) increasing crop production per acre because of increasing carbon dioxide in the atmosphere could make the 1989 estimated reduction very conservative.

Notice that none of the great environmental benefits described above has been the result of activities of people who call themselves environmentalists. Nor have government environmental regulations been a significant factor. Most beneficial changes resulted from efficiency in land use because of effective technologies, and because normal, responsible people tend to take care of their land. No amount of regulations could have created the enormous environmental benefits.

Sustainability. When our environmental gains are pointed out, environmentalists tend to reply: "but the gains are not sustainable. We will run out of resources." Ignored is the fact that technology *creates* resources by showing how to use the rock materials on which we walk. And we continuously create and substitute new common materials for rarer metals, such as plastic for steel, silica for copper in phone lines, and silicon chips for vacuum tubes.

The concept of sustainability is a pathetic goal. Technology multiplies mineral resources, just as it has multiplied our forests, soils, wildlife, and food. For a fuller discussion, see Dunn and Kinney (1996, pp. 138-151).

Paradox 2. Nature has fared the worst in nations where people are closest to nature, best, where people are most removed from nature.

Those who are most critical of the impact of humanity on the natural environment tell us that the worst thing that can happen to the environment is industrialization. They point out that the salvation of nature can only be achieved by our going back to the land or reversing technology. To believe this, they must ignore the following:

First, America's great environmental gains in the East occurred because *people got off land that was not efficient for agriculture.* They concentrated largely in metropolitan acres where they were farthest removed from nature. Even in the Midwest the current trend is for people to leave the land. In 1880, 43.8 percent of America's population were farmers (U.S. Department of Agriculture 1972); in the 1990s, less than 2 percent of the population are farmers (Wright 1998, p. 314). As farmers left the land, the natural environment improved in many ways. The process is continuing in the East and recently, in areas of the Midwest (Kilman, *op. cit.*).

The greatest stress on nature is where people are closest to nature. Going back to the land is environmental suicide.

Second, in low-technology, poor nations, where often more than 90 percent of the population are farmers, the natural environment suffers. In most poor nations where people are closest to nature, the stress on forests is severe. Ethiopia, for example, was once about 75 percent forested, but is now only about 1 percent forested. Ethiopians need the land for agriculture and the wood for fuel. Wildlife are depleted; soil erosion is excessive. *Only with cheap fuel and modern agriculture* can trees and wildlife return to Ethiopia.

Clearly, the greatest stress on nature is where people are closest to nature. *Going back to the land is environmental suicide.*

Paradox 3. If environmentalists achieve their major stated goals of turning back our technological clock, and of bringing us closer to nature, we will destroy nature as we know it.

First, let some of our prominent environmental leaders define their real goals:

Barry Commoner, former Socialist candidate for President: "We must go back to the spinning wheel, returning to a beatific state of endless drudge, labor six days a week, and exhaustion on Sunday" (Ray 1993, p. 77).

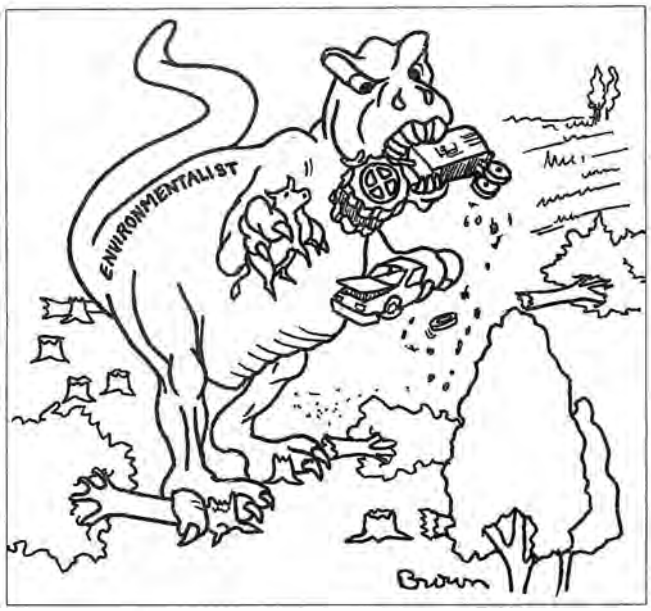
Maurice Strong, Socialist and Assistant Secretary General, U.N.: "It is clear that current lifestyles and consumption patterns of the affluent middle-class . . . involving high meat intake, consumption of large amounts of frozen and 'convenience' foods, ownership of motor vehicles, numerous electronic household appliances, home and workplace air conditioning, suburban housing, is not sustainable. . . . The United States is clearly the greatest risk" (Jasper 1992, p. 36).

Chellis Glendinning, author of the Neo-Luddite Manifesto: "We favor dismantling of the following destructive technologies: nuclear technologies, chemical technologies, genetic technologies, television, electromagnetic technologies, computer technologies" (Glendinning 1990).

Al Gore in his *Earth in the Balance* rails against "industrial civilization's terrible onslaught against the natural world," and industry's "unprecedented pattern of destruction" (Gore 1992, pp. 282, 245).

Paul Ehrlich, author of *The Population Bomb,* among other books, says: "There is no, I repeat no, conceivable technologic solution to the problems we face" (Efron 1984, p. 35).

Ted Turner, former owner of CNN, and environmental mega-funder: "The indigenous people were the ones that were right. I mean, they had their own religion, their own ethics, and their own technology. We just went down the wrong road" (Ray 1993, p. 80).



David Foreman, co-founder of Earth First!: "We must . . . reclaim the roads and plowed land, halt dam construction, tear down existing dams, free shackled rivers and return to wilderness millions and tens of millions of (acres of) presently settled land" (Ray 1990, p. 166).

Of course, the above environmentalists have not been clear about medical technology. To be consistent, they should insist that medical treatment for heart diseases, cancer or other such common ailments, should be only that available in, say, 1930 or 1900 or 1492 or 10,000 B.C., whatever their idealized time is. To my knowledge, none of the environmental leaders have done this.

The real beliefs of the greens, quoted above, do not appear in the major media. We are told that they are our environmental leaders—but they are not environmentalists at all; they are Luddites. They are in the tradition of Ned Ludd, who from 1811-1816, tried to reverse the course of industrialization by smashing machinery. Ludd thought that industrialization was costing jobs. The current breed of Luddites is far more dangerous because they have enormous political power and wealth, and they operate behind a fog created by a cooperative media. Most media strongly support the views of such greens as Al Gore, Maurice Strong, and Ted Turner.

A major characteristic of Luddites is that they stubbornly refuse to acknowledge the environmental gains they see around them. Thus, they cannot learn from history. Try to find in Gore's *Earth in the Balance* any mention of America's increased forests, wildlife and biodiversity or our reduced erosion. Yet Virginia, adjacent to Washington, D.C., and Gore's beautiful home state of Tennessee, are classic examples of great changes that have occurred.

The adamant refusal to acknowledge any environmental "up side" is also shown by the policy of Carol Browner, Administrator of EPA (who helped Gore write *Earth in the Balance*): In evaluating pesticides, EPA allows no benefits to be considered (Hurst 1994). This policy is both one-sided and short-sighted, like a business that bases its policies on only one side of its ledger. Reasonable decisions are virtually impossible.

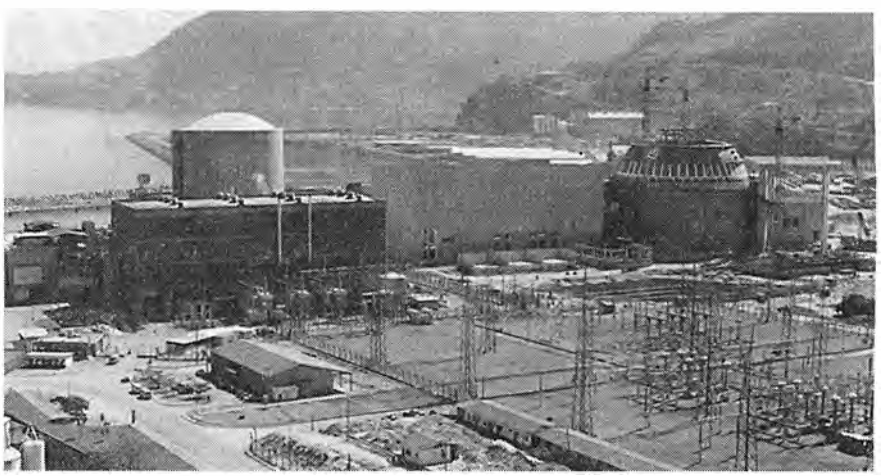
The stubborn one-sided view is very evident in the writing of Al Gore's hero, Rachel Carson. In her 1962 *Silent Spring,* in which she deplores the use of agricultural chemicals because they kill birds, she omitted one major fact: In the 20 years before the publication of her book, most bird populations were dramatically increasing. Further, a major cause of the increased bird populations was the use of the very agricultural chemicals she deplored. As I showed above, increased agricultural productivity per acre allowed us to release farm land. That unneeded land largely became wooded and able to support birds that need trees for their habitat. This thoroughly documented refutation of Carson's major thesis has never reached the general public.

Continued on page 13

ANS MEETING OF THE AMERICAS

Brazilian Optimism, U.S. Unreality Characterize Nuclear Meeting

by Colin Lowry



EIRNS

Brazil plans two new nuclear plants by 2015. Here, the 1300-MW Angra 2 plant, in construction.

Aside from the nuclear optimism expressed by the Brazilian speaker, the plenary session on "Opportunities and Challenges for Nuclear Science in the Americas" at the American Nuclear Society's winter meeting in Washington, D.C., Nov. 16, was full of gloom from U.S. officials who insisted that the fraudulent global warming agreements, combined with the "free market," must dictate the future of nuclear power.

Speaking for the Brazilian Minister of Science and Technology, Hugo Rodrigues outlined the achievements of the Brazilian nuclear program, its importance for the nation's development, and Brazil's optimistic plans for building two new plants by 2015, and expecting fusion power to be developed by 2025. "The nuclear field has played and will continue to play a key role in supporting the creation of a scientific and technological culture in Brazil," he said. Rodrigues is the director of FINEP, the government group that funds science research.

Brazil has an impressive cadre of about 3,000 nuclear scientists, Rodrigues said, and the government would like to invest more in nuclear technology research. "Nuclear science and technology is extremely important for Brazil, since it can guarantee a reliable supply of energy, resolve and help to understand society's problems, with the application of its techniques, and bring about technological advances in national industry."

Brazil also plans to complete the construction of the Angra 2 and Angra 3 nuclear power plants, and to increase the use of radioisotopes in medicine and industry. Rodrigues made no mention of the global warming treaty, or emissions targets, as reasons to pursue the development of nuclear energy. The Brazilian nuclear program forecasts that by 2020, nearly 50 percent of the world's electricity will be generated by nuclear fission reactors.

U.S. Focus on Warming Hoax

In contrast to Rodrigues, the U.S. officials uncritically cited the climate treaty-mandated emission restrictions as "good" for nuclear energy. Dr. Ernest Moniz, U.S. Department of Energy Undersecretary, talked about the importance for the nuclear industry of the climate treaty, which the United States delegation to the Buenos Aires meeting had just signed. He presented the global warming agreements positively, as a potential incentive for the building of new nuclear power plants in the United States, because nuclear plants have no "greenhouse gas" emissions. But then Moniz described the administration's approach to meeting the emissions targets as a "lowest-cost" approach, relying on the "free market" to decide the fate of the nuclear industry.

Incredibly, Moniz also praised deregulation of the electric power industry, and said it would be "good" for the nuclear industry because it would create new opportunities, just as deregulation has done for the telephone industry. (In reality, deregulation will further degrade the reliability of the U.S. power grid and cost consumers more.)

Moniz concluded on a pessimistic note, conceding that the future of the nuclear power industry in the United States "is unclear," and citing the difficulties of the "brain drain" on nuclear science, as almost no new students are being trained in these areas.

His speech was like a poor sales pitch, trying to placate nuclear professionals who know that the administration's so-called free market energy policy will destroy the remaining nuclear power plants still in operation. There have been no new orders for nuclear plants in 20 years in the United States. Further, electric power deregulation will make it impossible to recover the high capital investment needed to build nuclear power plants, leaving electric utility executives only lower-cost (in the short term) options, such as natural gas generators.

There was more gloom from David Waller, Deputy Director General of the International Atomic Energy Agency.

Waller estimated that nuclear-generated electricity will fall from 17 percent to only 8 percent worldwide, if current trends remain unchanged. He referenced the climate treaty and its requirement to slash carbon emissions, but he said that nuclear technology was the only economical option for generating electric power, and that it ought to be the priority of leading nations.

Contradictory U.S. Policy

The presentation by Richard Stratford, Director of Nuclear Affairs, U.S. Department of State, highlighted the inconsistent and often contradictory policies of the administration concerning nuclear power. Stratford first praised the broad peaceful uses of nuclear technology in agriculture, water desalination, medicine, and power generation, but then went on to stress that the global warming treaty mandated "cost-effective" solutions to meet emissions targets.

"Will carbon emissions targets mean more nuclear plants? Only if the government favors new nuclear plants," Stratford said. But the administration favors electric power deregulation, which Stratford said—speaking on his own behalf, and not for the State Department—"will likely hurt the nuclear industry, as cost is the big factor."

A question from the audience pointedly asked how the administration could be for the global warming treaty's carbon emissions targets, without supporting nuclear power? Stratford responded that the government could not openly support the nuclear industry, because this would be "advocacy." He said that the government was leaving the decision of how to meet the emissions targets to the electric power companies, which may choose nuclear power generators if they offer a "cost-effective" option.

This should have made it clear to the audience that those in the nuclear industry who believe that riding on the coattails of the global warming scare will be good for nuclear power, is foolish. No one addressed the fact that the same environmentalist groups that attacked nuclear power in the 1970s, are now pushing the global warming scare, using the same anti-development ideology. And no one addressed the irrelevance of a "cost-effectiveness" concept that leaves out the cost in human lives of *not* going nuclear.

Viewpoint

Continued from page 11

I stress: *rejecting technology is not the same as improving the environment*. Quite the opposite. For example, Dr. Norman Borlaug, the Nobel Prize winner for his green revolution work in poor nations, says that turning agriculture's technological clock back only to the late 1930s would result in our needing 437 million more acres of new agricultural land (Borlaug 1993). This is greater than America's land area east of the Mississippi River. *Our new woods and forests and much wildlife would disappear, and much of our current biodiversity would vanish.*

Let's turn agriculture's clock back to the 1890s and look at another environmental hazard, pollution. The Amish country of Pennsylvania is frozen in that period. It may be quaint and a tourist attraction but according to Dave Correll, director of Smithsonian Environmental Research Center: "It's perhaps the most polluted area in the Eastern United States," largely because of "prodigious quantities of manure" (Ross 1996).

Reversing agricultural technological progress would *create* a major environmental catastrophe. We must not let this happen.

Nitrogen-rich runoff from Amish farms is responsible for pollution of northern Chesapeake Bay. High nitrogen waters apparently cause blooms of phytoplankton that kill sea grass and blue crabs as well as other species.

In addition to the pollution, the 1890s need for pasture land for farm draft animals would further stress America's forests. If we used 1890s technology, Dr. Borlaug's 437 million extra acres needed with 1930s technology would be more like 500 to 600 million additional acres to produce the food we need for our present population.

Reversing agricultural technological progress would *create* a major environmental catastrophe. We must not let this happen.

James Dunn, Ph.D., a geologist, is the co-author, with J.E. Kinney, of Conservative Environmentalism, *published by Quorum Books (Westport, Conn.) in 1996.*

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What Ever Happened to Cold Fusion?

by Dr. Edmund Storms

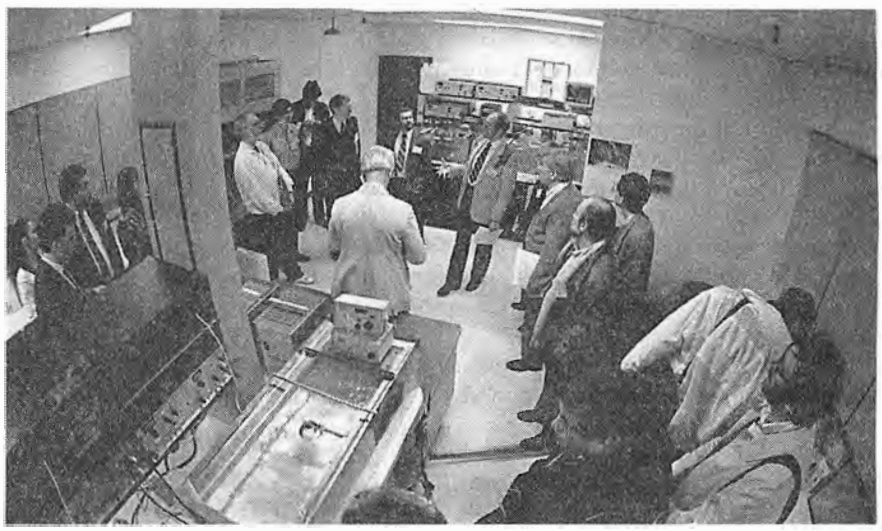
Cold fusion is still alive, though ailing. Regular conferences are being held by the devotees, the most recent ones being the international ICCF-7, in Vancouver in April;[1] the Cold Fusion and New Energy Symposium, Manchester, N.H., in October,[2] and the Sixth Russian Conference on Cold Nuclear Transmutation, Dagomys, Russia in early October.[3] Other conferences are being planned during regular meetings of several scientific societies in 1999. A well-balanced article appears in the November issue of *Wired* magazine, and web sites containing much useful information have been constructed by the Alternative Energy Institute[4] and the Institute for New Energy.[5] Slowly, information is being made available, in spite of broadly based skepticism.

More than nine years have passed since Profs. Stanley Pons and Martin Fleischmann first shocked, and then disgusted, the scientific community by claiming to cause a fusion reaction between deuterons within palladium deuteride.[6] The process was named "cold fusion" by Prof. Steve Jones,[7] who also claimed to see this reaction, although he later repudiated his earlier work and denounced claims for excess energy.

Where do these claims stand today?

On the one hand, the field has grown, and evidence is being published for a variety of nuclear reactions, in addition to fusion—the transmutation branch of the field. Consequently, the name cold fusion has been changed to chemically assisted nuclear reactions (CANR), in order to better describe the nature of the environment in which the broad range of nuclear activity is proposed to occur.

Claims are being supported by a growing body of increasingly well done and, in some cases, reproducible observations, and the results are being explained (slowly) by some very imaginative processes.[8-11] On the other hand, all of the large, well-funded efforts to study the effect have been abandoned. The study sponsored by EPRI (Electric Power Research Institute) at SRI (Stanford Research International) was closed down; the Center for New Hydrogen Energy (NHE) in Sapporo, Hokkaido, supported by the Japanese government, has been disbanded; the laboratory in France sponsored by the Japanese firm Technova, where Pons and Fleischmann worked, has been closed; the Japanese support of the work at SRI has ended; and work at ENEA, Frascati (Italy) has been cut back.



University of Utah

A briefing in April 1990 for press and scientists at the Pons-Fleischmann electrochemistry lab at the University of Utah, during the first international conference on cold fusion, held in Salt Lake City.

Fleischmann has returned to England and Pons has remained in France as a French citizen.[12] It would appear that efforts to demonstrate the reality of the claims have failed and that the field has been abandoned to the trash bin of bad science, as many critics have been saying is long overdue. How can these two opposite realities be reconciled?

A Stand-off Situation

First, we need to understand that all of the large efforts were undertaken with expectation of an easy demonstration and quick development of commercial products. This did not happen,

METHODS USED TO PRODUCE THE CANR EFFECT

- Electrolysis of liquids
- Plasma discharge between solids in a liquid
- Gas reaction with microcrystals
- Electric discharge in low pressure gas
- Phonon conduction through semiconductors
- Cavitation involving bubble formation (ultrasonic)
- Mechanical changes involving crack formation
- Sudden decomposition of hydride
- Biological systems

for reasons I will discuss later. As reproducible methods to produce the effect remained elusive, the skeptics were emboldened to further hinder funding for new research and to stop publication of results which escaped their initial efforts.

Second, absence of a clear path to commercialization provided a powerful argument even for open-minded people to wait until more basic research was done before risking additional money.

We are now in a stand-off situation. The phenomenon has been demonstrated to be real, but insufficient will exists in corporate and government institutions to move to the next level of understanding. The vocal skeptics have so tainted the field with claims of bad science, that few people want to risk being associated with this method of initiating nuclear reactions.

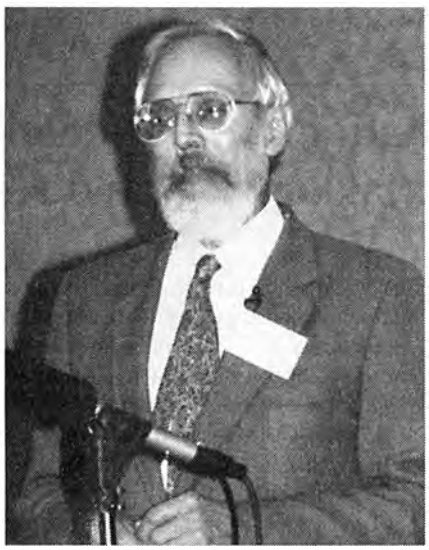
Why have people had such a hard time making the effect occur on demand, as is required for the effect to be accepted?

Several of the nine methods (Table 1) now known to initiate these anomalous nuclear reactions are very reproducible. For example, the ultrasonic method (see box) easily produces heat and helium, provided the technique is properly applied.[13] Several methods routinely produce transmutation products.[14,15]

On the other hand, the skeptical view has historically been obsessed with the electrolytic method, as first used by Pons and Fleischmann. This method has been frequently unsuccessful because the required properties of palladium, the material in which the effect occurs, are not uniform or easily duplicated. Only rare pieces of palladium, which do not crack when reacted with high concentrations of deuterium, are suitable.[16] The absence of certain impurities, such as carbon and oxygen, and the presence of certain other impurities, such as silver and boron, have been found to improve success. Most important is the condition of the surface where the nuclear reactions actually occur.[17,18] All of this information has been slowly acquired but, unfortunately, it is frequently not used by people attempting to duplicate the method.

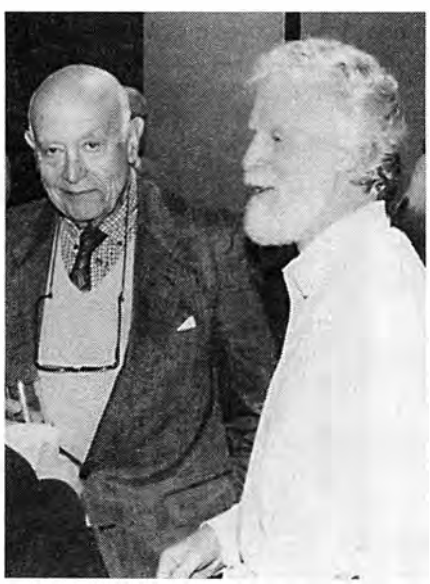
For example, the NHE laboratory in Japan did not take many of these important variables into account. Consequently, much of the palladium studied was later demonstrated to be incapable of supporting the necessary high deuterium concentration.

To make matters worse, researchers who have attempted replication in the past have often failed to follow the necessary instructions, preferring instead to use their own approach. When the work was done properly, such as in France where the Pons-Fleischmann instructions were followed exactly, the replication was completely successful.[19,20]



Courtesy of *Infinite Energy*

"The vocal skeptics have so tainted the field with claims of bad science, that few people want to risk being associated with this method of initiating nuclear reactions." Here, the author giving a presentation at the Cold Fusion and New Energy Symposium in Oct. 1998.



Edmund Storms

Roger Stringham (right) at the ICCF-7 in Vancouver.

Palladium and Physicists

We can now conclude that many past attempts to duplicate the origiinal cold fusion claims have failed because poor palladium was studied and improper procedures were used. Why hasn't this realization had a greater effect on the general attitude?

When nuclear processes are claimed, physicists feel qualified to suggest and evaluate the methods used to support the claims. Unfortunately, however, this influential branch of science has a narrow view of nature. For example, when physicists explore nuclear processes they are dealing with a phenomenon which is normally independent of surrounding materials. Fission, for example takes place regardless of the chemical structure in which the uranium or plutonium is located. Hot fusion is produced in a plasma, a gaseous form of matter, and then only when the temperature is extremely high. Evidence of such reactions is easily acquired, using various radiation detectors.

Consequently, physicists generally ignore the nature of the palladium and, instead, insist on looking for radiation. Their attitude is that any old palladium will do just as well. After all, the reactions should not occur at all, according to currently accepted theory—so why should a little difference in the palladium matter?

After many frustrated studies, everyone is willing to admit that very little radiation is emitted even when excess energy is being produced. This is not to say that no radiation is produced. The little that is seen still must be explained, rather than being ignored as is currently the case. From this experience, physicists naturally conclude that the claimed nuclear reactions are not occurring, and that the heat results from something else.

Because the large amount of heat is not believed to be nuclear in origin, most physicists are no longer interested. After all, calorimetry, the measurement of heat, is not very interesting and can have various errors which, in their minds, can account for the supposed heat. With physics being the voice of science these days, this bias causes the CANR implications for materials science to be completely ignored.

Yes, people have studied the effect of annealing temperature and time, they have examined palladium containing a few different impurities, and they have used different procedures to apply the electrolytic current. These efforts barely scratch the surface of potential variables, while ignoring the effects these changes would have on the important properties of palladium and its hydrogen compound. As a result, the ability to find active palladium has been compromised. Meanwhile, none of this work is acknowledged by most physicists as having any relevance to achieving reproducibility–the lack of reproducibility being caused by the impossibility of initiating a nuclear reaction under these conditions in the first place.

A Frustrating Problem

Where does this leave us?

We are faced with a frustrating problem. Hundreds of examples of excess energy production have been published; dozens of anomalous nuclear products have been detected; several independent measurements of heat and helium production show a clear, quantitative relationship between these two products;[21] relationships between certain properties of the palladium and heat production have been demonstrated;[22-24] most errors have been reduced to insignificant levels in some studies; a few methods are completely

Sonic Cavitation: A Reproducible Method For Making Heat and Helium

Before cold fusion was even an idea, Roger Stringham was toying with ultrasonic cavitation. After Pons and Fleischmann gave people permission to try unusual methods for producing a fusion reaction, Stringham tried loading palladium with deuterium using bubble collapse, and had surprising success. Russ George joined the work several years later.

When a sufficiently intense sound wave is passed through liquid water, bubbles are formed which then collapse as the wave passes. If these bubbles collapse next to a solid surface, they inject a high temperature plasma of decomposed water, during a very brief time, just before they disappear. This is the same process that causes cavitation damage to ship propellers.

Figure 1 shows an idealized bubble just as it is starting to inject its contents into the surface.

If the solid is palladium and the liquid is heavy water, the injected material is a mixture of D+ and O−. The deuterium ions rapidly diffuse from the injection site and gradually build up a high, local concentration, as more material is injected by a steady rain of bubbles.

The oxygen stays on the surface and gradually forms palladium oxide, visible as a colored stain. If the conditions are just right, the local deuterium concentrations can reach values required for producing a nuclear reaction. The advantage of this process is that surface barriers and cracks are not as important as they are when the more gentle electrolytic method is used. In fact, the cavitation method is even able to load silver and copper (two elements which do not normally dissolve hydrogen), and obtain excess power from the effort.[1]

The Measurements

How do we know an anomalous process is actually occurring?

Two types of measurement have been made. In the first, the power applied to the cell to make the acoustic waves is subtracted from the power leaving the cell as heat, with the difference giving the amount of power produced by an anomalous process. As can be seen in Figure 2, the observed power is frequently above that obtained when an internal heater is used instead of sonic heating. Excess power reached 124 watts in this case, and has been higher in other experiments. This quantity of power can not be explained by any conventional process or error.

In the second measurement, the presence of helium is looked for in the argon gas which fills the vapor space within the apparatus. Amounts between 50 parts per million and 500 ppm have been seen. These values are significantly above a concentration of 5.2 ppm known to be in the surrounding air. Therefore, this helium could not have originated from a leak, and no conventional source could be identified within the apparatus.

More information about the work of these two scientists can be obtained

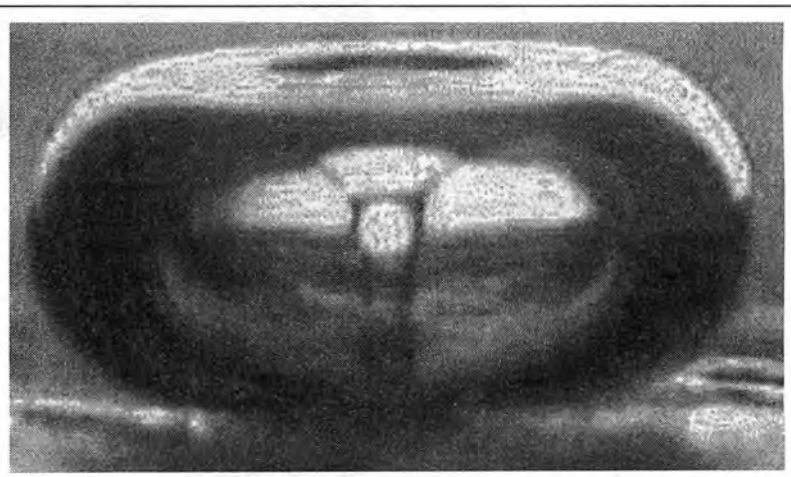


Figure 1
IDEALIZED SONIC BUBBLE, JUST BEFORE COLLAPSE ON A SURFACE

reproducible; and, finally, theoretical understanding is growing.

In spite of all this support, skepticism rules supreme; papers supporting the claims are routinely rejected; and patents are still not being issued by the nuclear section of U.S. Patent Office. A reasonable person might ask, "What does it take these days to change a bias in science?"

What ever happened to the idea of open-minded inquiry? Has science lost its way?

Edmund Storms retired in 1991 from Los Alamos National Laboratory in New Mexico, where he had worked for 32 years. His research there was on the SP100 space nuclear program and space nuclear propulsion programs. His review of the 7th International Conference on Cold Fusion appears in the Summer 1998 issue of 21st Century, *p. 15.*

Notes

1. E.K. Storms, "The 7th International Conference on Cold Fusion, The Latest Word about

from the web site written by Russ George for E-Quest Sciences.[2] Roger Stringham now has a separate company for developing the process, First Gate Energies.

Although Stringham and George have no trouble producing excess energy, this reliability was earned only after much experimentation. An independent attempt by Scott Little to duplicate the results, without guidance, so far has failed.[3]

Once again, we must acknowledge the value of experience in making even the robust methods work on command.

Notes

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2. R. Stringham and R. George, http://www.hooked.net/~rgeorge/sonof.html.
3. S. Little, www.eden.com/~little

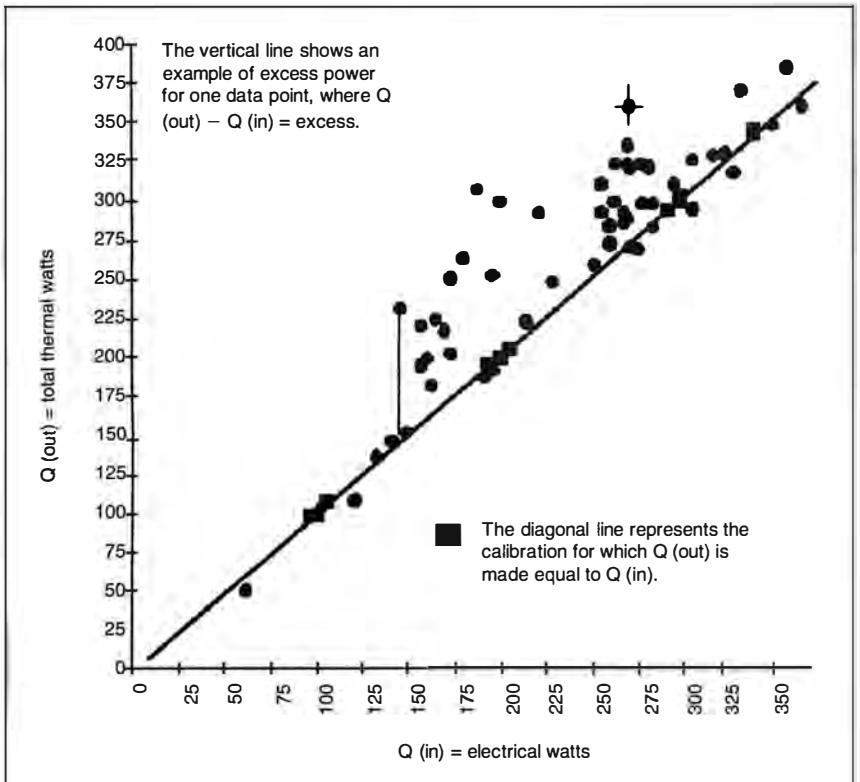

Figure 2
COMPARISON BETWEEN APPLIED ELECTRICAL POWER AND MEASURED THERMAL POWER IN SONIC CAVITATION
The diagonal line is based on a calibration during which electric power was applied using an internal heater. Points showing excess power fall above this line. This work was done at SRI in Stanford.

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2. "Cold Fusion and New Energy Symposium," sponsored by *Infinite Energy* magazine, Manchester, N.H., Oct. 11, 1998.
3. The Sixth Russian Conference on Cold Nuclear Transmutation, Sept. 28-Oct. 5, 1998, Dagomys (near Sochi), Russia. The following subjects were discussed: (1) Experimental researches of cold fusion and nuclear transmutation; (2) cold fusion and nuclear transmutation theoretical models; and (3) cold fusion applied technologies and devices.
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5. Institute for New Energy; see www.padrak.com/ine.
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7. S.E. Jones, E.P. Palmer, J.B. Czirr, D.L. Decker, G.L. Jensen, J.M.S. Thorne, F. Taylor, and J. Rafelski, "Observation of Cold Nuclear Fusion in Condensed Matter," *Nature,* Vol. 338 (1989), p. 737.
8. E.K. Storms, "Review of Experimental Observations about the Cold Fusion Effect,"*Fusion Technol.,* Vol. 20 (1991), p. 433.
9. E.K. Storms, "Cold Fusion Revisited," *Infinite Energy,* Vol. 4, No. 21 (1998), p. 16.
10. E.K. Storms, "A Review of the Cold Fusion Effect," *J. Sci. Exploration,* Vol. 10, No. 2 (1996), p. 185. (The full text can be found in: http://www.jse/storms/1.html.)
11. E.K. Storms, "Cold Fusion, An Outcast of Science," *21st Century Science & Technology,* Winter 1997/1998, p. 19.
12. Charles Platt, "What if Cold Fusion is Real?," *Wired,* Nov. 1998, p. 172.
13. R. Stringham and R. George, http://www.hooked.net/~rgeorge/sonof.html.
14. G.H. Miley, M.J. Name, J.A. Williams, J.A. Patterson, J. Nix, D. Cravens, and H. Hora, "Quantitative Observation of Transmutation Products Occurring in Thin-Film Coated Microspheres During Electrolysis," *The Sixth International Conference on Cold Fusion,* Progress in New Hydrogen Energy (Ed. M. Okamoto), Oct. 13-18, 1996, Hokkaido, Japan, Vol. 2, p. 629.
15. T. Mizuno, T. Ohmori, T. Akimoto, K. Kurokawa, M. Kitaichi, K. Inoda, K. Azumi, S. Simokawa and M. Enyo, "Isotopic Distribution for the Elements Evolved in Palladium Cathode after Electrolysis in D_2O Solution,"*The Sixth International Conference on Cold Fusion, Progress in New Hydrogen Energy* (Ed. M. Okamoto) Oct. 13-18, 1996, Hokkaido, Japan, Vol. 2, p. 665.
T. Mizuno, K. Inoda, T. Akimoto, K. Azumi, M. Kitaichi, K. Kurokawa, T. Ohmori and M. Enyo, "Formation of ^{197}Pt Radioisotopes in Solid State Electrolyte Treated by High Temperature Electrolysis in D_2 Gas," *Infinite Energy,* Vol. 1, No. 4 (1995), p. 9.
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17. E.K. Storms, "Formation of β–PdD Containing High Deuterium Concentration Using Electrolysis of Heavy-Water," *J. Alloys and Compounds,* Vol. 268 (1998), p. 89.

Continued on page 18

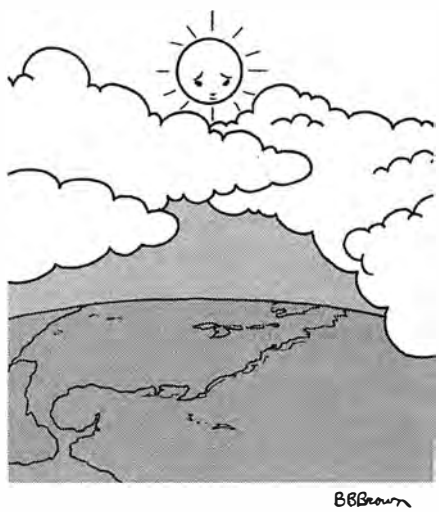
The Lightning Rod

My Dear Friends:

I beg you to excuse my prolonged absence from these pages, by accepting my assurances, once again, that what passes for "news" these days far surpasses my modest attempts at satire. What could be more trying, for a scientific mind, than to wade through the apocalyptic scientific pronouncements in the daily press? The Sun is frying us because we used too much air-conditioning, or, the substances that made America's crops abundant are now poisoning us, and—but, I must not overwhelm you with the very factoids in which you may already be drowning.

Instead, I want to report on a recent communication proposing a truly apocalyptic scenario, that concerns one of my favorite investigative topics: electrical power. The writer, Jim Muckerheide, is a nuclear engineer from Boston, a place, of course, dear to my heart.

Borrowing terminology from the nuclear industry, which is surely familiar to most readers, Jim asks us to consider the consequences of a "maximum credible accident," if this nation were solar-powered . But solar energy is benign and accident proof, the naivest might object. Not so, says Mother Nature.



Recall the nightly newscasts during the spring with its stories of fires burning in Mexico for weeks, with smoke extending into the southern United States—"smoke covering thousands of square miles . . . pervasive smoke from the ground, with evening darkness at noon, and soot pervading everything. Or think of the weeks of fires in central Florida," Jim writes.

Now imagine, Jim says, personally depending on solar power. Imagine your industries and transportation and water supplies and lights depending on solar power, or on the limited back-up power and fuel that are not capable of covering an extended duration, over an extended area—even were society to spend the money to have such back-up systems.

Now, Jim continues, "ask the solar collector engineers about performance assessment of the extent of solar power loss from current smoke distribution conditions. Ask energy system analysts about the effect of that power loss if there were a solar powered economy. A 10 percent loss can be devastating. Picture 30 percent or more."

Jim also asks us to imagine dependence on solar power during and following a major volcanic eruption, such as Krakatoa's "year without a summer" in 1884. Since the 1970s, he says, solar energy analysis has failed to recognize the actual experience of such atmospheric interruptions in solar radiation, greater than Mt. St. Helens and Mt. Pinatubo. This would be the "maximum credible accident" for solar power.

The consequences? "Economies collapse, food and water are lost. We should expect 100 million deaths, potentially exceeding any human population disaster since the 'black death' of the 14th century. It could rival all-out nuclear war."

This is no hypothetical accident with hypothetical health effects, Jim points out. "Even if society were ultimately foolish enough to actually depend on solar energy, requiring 50 to 100 square miles of collectors to produce the energy of one nuclear plant on 2 acres, and even if solar could be made more cost effective, it would still have the potential to leave large future populations without the energy essential to life."

So, dear readers, when you next suffer an apocalyptic deluge of factoids from an ignorant-by-choice environmentalist, inform them of this "maximum credible accident" scenario, courtesy of their revered Mother Nature. Perhaps it may prompt a small-scale eruption of reason, or at the very least, a desire to ask some real scientific questions.

I remain,

Yr. obedient servant,

Cold Fusion

Continued from page 17

18. E.K. Storms, "The Nature of the Energy-Active State in Pd-D," *Infinite Energy*, Vol. 1, Nos. 5-6 (1996), p. 77.
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20. G. Lonchampt, J.-P. Biberian, L. Bonnetain and J. Delepine, "Excess Heat Measurement with Pons and Fleischmann Type Cells," *Proc. of the Seventh International Conference on Cold Fusion*, April 19-24, 1998, Vancouver, p. 202 (publ. by ENECO, Salt Lake City).
21. E.K. Storms. See Note 1.
22. E.K. Storms. See Note 16.
23. M. McKubre, B. Bush, S. Crouch-Baker, A. Hauser, N. Jevtic, S. Smedley, M. Srinivasan, F. Tanzella, M. Williams, and S. Wing, "Loading, Calorimetric and Nuclear Investigation of the D/Pd System," *Proc. Fourth International Conference on Cold Fusion*, Lahaina, Maui, Dec. 6-9, 1993. EPRI TR-104188-V1 (1994), published by Electric Power Research Institute, 3412 Hillview Ave., Palo Alto, CA 94304, Vol. 1, p. 5.
    M.C.H. McKubre, S. Crouch-Baker, F.L. Tanzella, S.I. Smedley, M. Williams, S. Wing, M. Maly-Schreiber, R.C. Rocha-Fiho, P.C. Searson, J.G. Pronko, and D.A. Kohler, "Development of Advanced Concepts for Nuclear Processes in Deuterated Metals," Final Report, EPRI TR-104195, Aug. 1994.
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SHOCKING U.N. REPORT SHOWS AFRICAN HOLOCAUST

Implosion of Population Growth Rate Continues through 1998

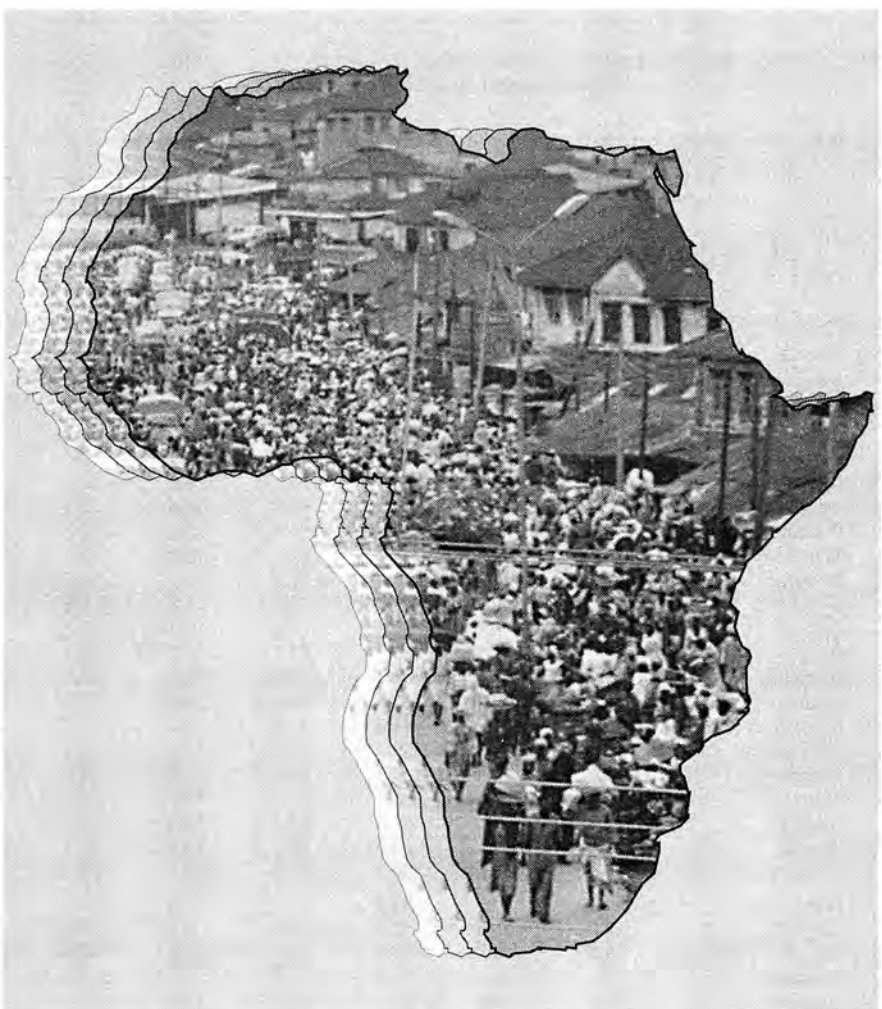
Thirty million Africans "disappeared" from the African population, relative to the 1996 count, according to the United Nations Population Division's 1998 report—deaths caused by the spread of AIDS and warfare. The forecast for the future is even more grim, as average life expectancy plummets.

by Paul Gallagher

There was a time when a congress of royal astronomers met for weeks to calculate—or, at least, to estimate—the rate at which a huge asteroid was rushing away from their planet. Despite certain learned disagreements, these eminents laid down the basic parameters (the "ballpark agreed upon by everybody") concerning the great speed of supposed recession of the asteroid; a speed so great, some claimed, that it must soon disintegrate. Then, one fellow discovered a very unfortunate flaw in the calculations. They all had the *sign* of the velocity wrong. The asteroid was rushing, not away, but straight toward their planet, and gathering speed! His shocking new results were just about to be taken up for discussion, when the catastrophic collision brought the congress—and much else besides—to an abrupt and tragic end.

So it is with the human "population explosion." The growth rate of the world's population is, in fact, rushing toward zero, and toward the potential of a catastrophic collapse like the one unleashed in the 14th century, the epoch of the Black Death.

One year ago in *21st Century Science & Technology,* we forecast that the human population, as a whole, would be falling by sometime in the first decade of the coming century, unless we reversed—and rapidly—the accelerating breakdown of the physical economies of the world's nations. Recent, shocking reports from the United Nations Population Division and the U.S. Census Bureau, show that there is no reason now to change that forecast.

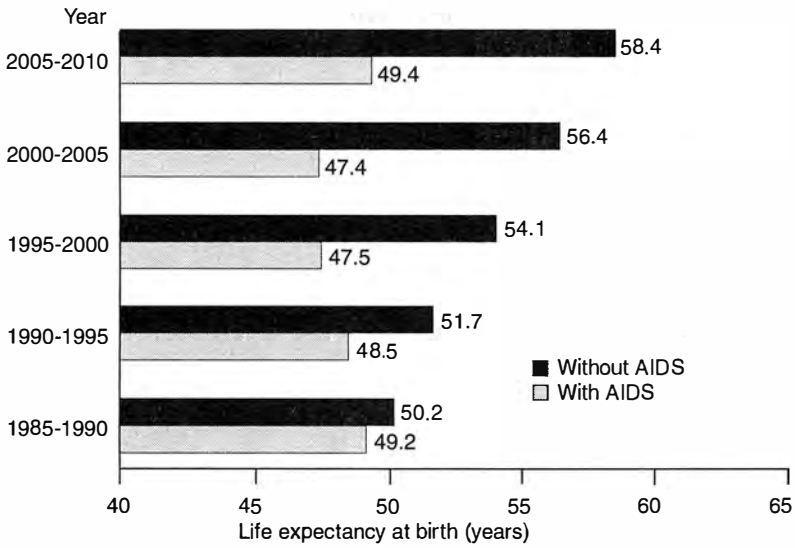


Uwe Frieseke/EIRNS

Pictured is Ibadan, Nigeria. Life expectancy in Africa's most populous nation, dropped to 53.6 years in 1998.

Recent "disagreements," debates, and fights among demographers and commentators on this question, are rapidly coming to an end, despite dishonest holdouts among Malthusians who *advocate* negative population growth. For ex-

LIFE EXPECTANCY AT BIRTH IN 29 AFRICAN COUNTRIES, WITH AND WITHOUT AIDS (1985-1990 AND 2005-2010)



Source: United Nations Population Division, *World Population Prospects: The 1998 Revision*

Table 1
DEMOGRAPHIC INDICATORS WITH AND WITHOUT AIDS: 1998

	Growth rate[1]		Life expectancy		Crude death rate[2]	
Country	With AIDS	Without AIDS	With AIDS	Without AIDS	With AIDS	Without AIDS
Botswana	1.1	2.4	40.1	61.5	20.9	8.6
Burkina Faso	2.7	3.2	46.1	55.4	17.7	13.1
Burundi	3.5	4.0	45.6	55.4	17.4	12.2
Cameroon	2.8	3.2	51.4	58.6	14.0	10.6
Central Af. Republic	2.0	2.5	46.8	56.3	16.8	12.0
Congo (Brazzaville)	2.2	2.7	47.1	57.2	16.5	11.3
Congo (Kinshasa)	3.0	3.3	49.3	54.4	15.2	12.7
Côte d'Ivoire	2.4	3.0	46.2	56.5	16.1	10.7
Ethiopia	2.2	2.9	40.9	50.9	21.3	15.0
Kenya	1.7	2.5	47.6	65.6	14.2	6.2
Lesotho	1.9	2.3	54.0	62.0	12.8	9.2
Malawi	1.7	2.7	36.6	51.1	23.7	14.4
Namibia	1.6	2.9	41.5	65.3	19.8	7.5
Nigeria	3.0	3.2	53.6	57.8	13.0	10.9
Rwanda	2.5	3.2	41.9	53.9	19.0	12.2
South Africa	1.4	1.9	55.7	65.4	12.3	7.8
Swaziland	2.0	3.2	38.5	58.1	21.4	10.1
Tanzania	2.1	2.6	46.4	55.2	16.7	12.1
Uganda	2.8	3.5	42.6	54.1	19.0	12.5
Zambia	2.1	3.3	37.1	56.2	22.6	11.4
Zimbabwe	1.1	2.5	39.2	64.9	20.1	6.2
Brazil	1.2	1.5	64.4	71.4	8.5	5.6
Guyana	−0.5	−0.3	62.3	65.7	8.7	7.3
Haiti	1.5	2.0	51.4	55.5	14.2	12.6
Honduras	2.3	2.5	65.0	69.2	7.0	5.5
Burma	1.6	1.8	54.5	57.1	12.5	11.2
Cambodia	2.5	2.7	48.0	50.7	16.5	15.0
Thailand	1.0	1.1	69.0	71.3	7.1	6.1

Notes
1. Growth rate is given as a percentage.
2. Deaths per 1,000 population.

Source: U.S. Bureau of the Census, International Data Base and unpublished tables

ample, the United Nations Fund for Population Affairs (UNFPA), which convened the notorious 1994 "Cairo Conference" on world population, continues to "warn" of rapid global population growth. (At that conference, the policy of supra-national enforcement of zero population growth, nation by nation, was beaten back by allied efforts of the Vatican, Muslim nations, and forces influenced by Lyndon LaRouche and the Schiller Institute.)

But the UNFPA is not a demographic agency, though it has usurped an international repute as such. Rather, it is a Malthusian advocacy agency, which receives, publicizes, and misuses the actual population data gathered by the U.N. Population Division. The latter *is* a demographic agency, part of the U.N.'s Department of Economic and Social Affairs (DESA), and actually counts people, in collaboration with national governments. The Population Division's director, Dr. Joseph Chamie, released a *1998 Revision* of the U.N.'s worldwide population estimates Oct. 28, which revealed a devastating collapse of population growth in Africa—an actual holocaust.

In the *1998 Revision,* the estimated population of the African continent was suddenly dropped by 30 million, relative to the 1996 estimate and its updates, and the world population estimate fell by the same amount. *Thirty million persons "disappeared" from the African population!* Dr. Chamie, in releasing the report, said that the average life expectancy in some nations of Africa "is falling like a stone."

Two Continents at Zero Growth?

"AIDS' Long Shadow," headlined *The Washington Post,* Oct. 29, in reporting the release of the U.N. Population Division's *Revision.* According to the report, 29 African countries, with two-thirds of Africa's population, have adult AIDS infection rates above 2 percent; most of them have 5 to 10 percent, or more. The average life expectancy at birth, for all these countries, has plummeted to 47 years.

This level cries to heaven at the end of the 20th century—it was characteristic of the United States early in the 19th century, before the coming of modern medicine and public hospitals. Life expectancy in the United States, Western Europe, and Japan, now is in the range of 80 years.

The "long shadow" is, in fact, that of disease *and* war: The devastating impact of AIDS and its co-factor infectious diseases, among others; and the genocidal wars which have been spreading from the central "Great Lakes" region of Africa since 1991. Some examples of its impact:

- In Zimbabwe, life expectancy is reported as falling from 52 years in 1990-1995, to 44 years in 1995-2000, and 41 years in 2000-2005.
- In Botswana, life expectancy is reported as falling from 61 years in 1990-1995, to 47 years in 1995-2000, and 41 years in 2000-2005.
- In South Africa, life expectancy is reported as falling from 59 years in 1990-1995, to 45 years in 2005-2010.

Moreover, the *1998 Revision* had not been out a month, when a new report by the U.S. Census Bureau, also on AIDS and African demographics, made even those figures appear optimistic. It had been the Census Bureau, in a May 1994 report ignored by the world press, which first showed the leaping death rates and falling life expectancies in Africa.

Now, in November 1998, the Census Bureau charted 21 of the same nations in Africa, and indicated an average expectancy of, not 47 but 45.1 years, with Botswana, Malawi, Zambia, Zimbabwe, and Swaziland all down to 40 years or less. The crude death rates in nearly all of these 21 nations had, as of 1998, risen by 50 to 100 percent since the onset of the AIDS pandemic (see Table 1).

The appearance of these shocking reports opens up a paradox, like that of the metaphorical asteroid, as to whether the human population of Africa, as a whole, is still growing at all. On the one hand, the *1998 Revision,* despite the tragedy it presents, states that Africa's population is still increasing by 17 million persons per year. Against this, is the startling fact that the U.N. Population Division's October *1998 Revision* reports Africa's population to be 749 million, whereas UNFPA's *State of the World Population, 1998* published only two months earlier, had claimed that the African population was 778.5 million!

In fact, UNFPA's 1997 report gave the African population, a year earlier, as 758.4 million, nearly 10 million more than it is now reported to be, after a year's "growth." Tens of millions of Africans have "disappeared."

The same paradox appears in detail, in respect to the most important nations of Africa. South Africa's population, reported by UNFPA to be 43.3 million in 1997 and 44.3 million in 1998, is now, according to the Population Division—39.4 million. Nigeria, counted as 118.4 million in 1997, and 121.8 million in 1998, is now 106.4 million! Sudan falls from 28.5 to 28.3 million; Ethiopia from 62.1 to 59.6 million; Uganda from 21.3 to 20.5 million; Zimbabwe from 11.9 to 11.4 million; and so on. Where may one find here an increase of 17 million per year?

Behind these contradictions lie two processes: first, the cruel ravages of spiking mortality rates in sub-Saharan Africa, dragging the population's growth *down* toward zero and below; second, the cruel deceptions of UNFPA in the 1990s, using "growth rates" annually punched into a computer program, to maintain the Malthusian fiction of runaway population by fudging figures *up.* This has been the stock-in-trade of all those agencies, like the notorious Worldwatch Institute, which, on the basis of a mere Malthusian advocacy, have fraudulently claimed demographic "expertise."

Table 2
NATIONS WITH NEGATIVE OR ZERO POPULATION GROWTH (1998)

Nations with negative population growth	Nations with zero population growth
Burundi	Gabon
Ethiopia	Lesotho
Kenya	Japan
Somalia	Czech Republic
Uganda	Poland
Zimbabwe	Slovakia
Morocco	Netherlands
Namibia	Switzerland
Iraq	Georgia
Jordan	Tajikistan
Lebanon	Uzbekistan
Kuwait	Cuba
Bulgaria	Melanesia
Romania	New Caledonia
Estonia	Vanuatu
Latvia	
Lithuania	
Albania	
Bosnia-Herzegovina	
Italy	
Macedonia	
Spain	
Austria	
Belgium	
Germany	
Armenia	
Russia	
Ukraine	
Paraguay	
Dominican Republic	
Trinidad and Tobago	
North Korea[1]	

Notes
1. Not as reported by U.S. Census Bureau, but based on U.S. State Department estimates of 1 to 2 million deaths by starvation in 1997-1998—the death of 5 to 9 percent of the population.

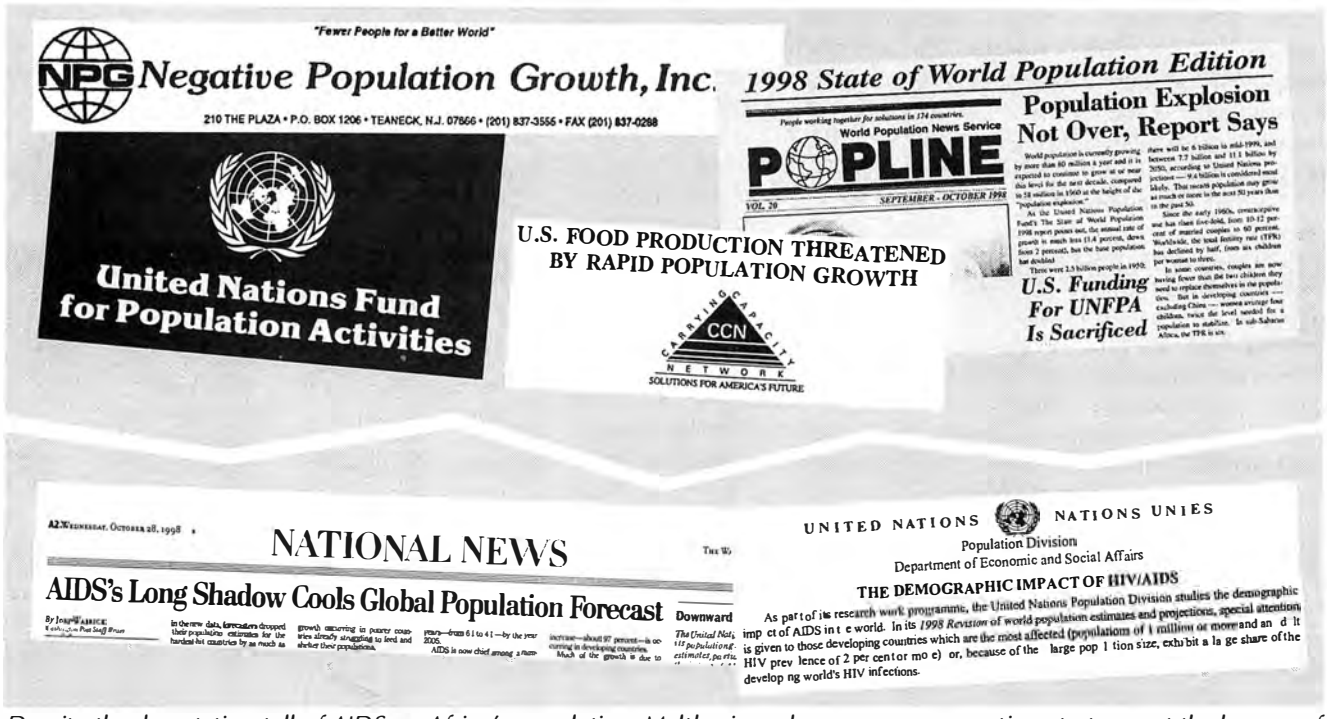
Sources: UNFPA, 1998 vs. 1997 reports and U.S. Census Bureau, 1998 vs. 1997 reports, as compared by the author

An Ongoing Holocaust

Thirty million Africans have not died of disease and war from August to October; but an ongoing holocaust of the African population has been revealed, which has been deliberately covered up by the UNFPA and related "demographics."

In contrast to the disarray of U.N. demographics caused by UNFPA's dishonesty, the U.S. Census Bureau data appear more consistent, but the paradox remains. The Census Bureau's *1998 Mid-Year Report* shows a growth of only about 10 million persons in the total African population since mid-1997. This would be a lingering growth of just over 1.3 percent per year, only very slightly above the current worldwide growth rate, which falls every year.

Note that in Table 1, the actual growth rate ("Growth rate with AIDS") column is positive for all 21 African countries listed. *But,* if one compares, nation by nation, the population given by the Census Bureau's *Mid-Year 1997* and *Mid-Year 1998* reports, one finds that there appear to be fewer people,



Despite the devastating toll of AIDS on Africa's population, Malthusian advocacy groups continue to trumpet the horrors of "overpopulation."

one year later, in five of those countries, and in three others in Africa. Two more nations in the list appear to be at zero growth.

Based upon these comparisons—not upon the momentary growth rates currently reported by the demographic agencies—Table 2 lists 32 nations worldwide which apparently have falling populations now, including 8 African nations, and 15 more nations apparently at zero growth. This is without taking into account the shockers in the U.N. Population Division's *1998 Revision,* already discussed, which in significant cases lower these figures further.

Genocidal Process

The full weight of the genocidal process unleashed in Africa, since the shutdown in the 1970s of long-term credit and aid to the entire continent below the Sahara, continues to elude even the honest demographic agencies. They know that one entire continent of the inhabited five—namely, all of Europe from the Atlantic to the Urals, with Asian Russia as well—is at zero population growth, and about to decline. Even more than the extremely low birth rates of Western Europe's post-industrial paradigm, this decline is caused by the physical-economic collapse of Central and Eastern Europe, under a savage "looting capitalism" in the 1990s, and the frightening increases in crude death rates there.

But these demographic agencies now face the prospect of a second continent—Africa—going into human population decline, at a catastrophe-driven rate, too rapid and too sudden for the uncertain national statistics of the afflicted nations to keep track.

LaRouche's Holocaust Forecast

In 1974, Robert McNamara, then head of the World Bank and speaking for the international financial community, publicly "red-lined" sub-Saharan Africa, declaring it a "Fourth World," or *terra incognita,* where long-term lending and investment were no longer worthwhile.

Economist Lyndon LaRouche immediately reacted to "body-count" McNamara's pronouncement with a forecast: Were this red-lining carried out, the results in the next decades, LaRouche said, would unleash a biological holocaust from that continent, in which old pandemics would return in force and new ones emerge, taking advantage of lowered barriers of species immunity. LaRouche initiated a Biological Holocaust Task Force among his associates and scientific collaborators, to discover and promote the breakthroughs in biophysics necessary to attack these worsening pandemics. (The Fusion Energy Foundation, and now, *21st Century Science & Technology,* have continued this work to date.)

The evil policy toward Africa propounded 25 years ago by Robert Mc Namara, has been brutally carried out. Many African countries have fewer miles of railroads today, less developed electricity and sanitation grids, and far fewer hospital beds per population, than they had in the 1970s. Their foreign debt is greater by the demon of compounded and capitalized interest; at the same time, they have been making net transfers of wealth out of the country continuously over that period, looted ruthlessly.

Today, the international minerals cartels still present in Africa are eagerly preparing to feast on regions "cleared," or being cleared, of people by war fighting. British policy, backed or tolerated by the United States, has built up the "new strongmen" of Central Africa, led by Uganda's Museveni, who have pursued the genocidal Tutsi vs. Hutu warfare which has spread, since 1994, to involve nine nations of the region.

The forecast LaRouche made in 1974, is graphically borne out in the mortality

rates and life expectancies of the Census Bureau and U.N. reports: These reported "facts" are a moral assault and challenge to humanity.

The pandemics involved, centered upon AIDS and its co-factors, particularly tuberculosis, have had an impact especially difficult for demographic agencies to forecast, for reason of the age groups that are predominantly killed by these diseases. Pandemics which sharply increase infant mortality, can lead to an "offsetting" increase in the birth rates of the affected nations, but those which sharply increase the mortality of adults below middle age—and both AIDS and constant warfare are such pandemics—can cause, in themselves, decreases in the birth rates, which unpredictably magnify the impact of rising death rates on population.

The figures for the entire human population, given in the *1998 Revision* by the U.N. Population Division, is 5.901 billion. This is 30 million persons fewer than claimed by the UNFPA's 1998 *State of the World's Population,* and 23 million fewer than the Census Bureau's latest estimate. The *Revision* claims a current human growth of 78 million persons per year, far from the 93 million annually, of which one heard only in 1993. The growth has fallen—at least—to 1.29 percent per year.

And perhaps it has fallen further. The 1997 U.N. figure for world population was 5.849 billion. Either that should have been considerably lower in reality, or, the increase from 1997 to 1998 was only about 52 million people—a growth of well *under 1 percent.* And if the 1997 figure is declared "revised," then the last two years' growth rate will be below the 1.29 to 1.30 percent currently given out. As recently as 1991-1992, that rate was said to be 1.7 percent per year, so there has been, by demographic standards, a rapid and drastic drop, that is still accelerating.

A notable, and happy, exception to this picture is China. While its current population growth is low, about 1.25 percent annually, that rate has jumped from 0.9 percent in the past few years. The only major nation whose physical economy is rapidly growing in real productive terms, China may be the only nation whose population growth rate is significantly increasing.

Chinese President Speaks On Science in Novosibirsk

Chinese President Jiang Zemin visited Russia in late November, and gave a speech on the importance of science and creativity for economic and social development, Nov. 24, before the scientific and technological community in the Science City of Novosibirsk. Jiang also called for China and Russia to work together in science and other areas. He spoke in Russian; the English translation is as reported by People's Daily.

Stuart Lewis/EIRNS

Chinese President Jiang Zemin reached agreements on the Eurasian Land-Bridge with both Russia and Japan in November. Here, Jiang at his October 1997 meeting with President Clinton.

I have long heard about the Science City of Novosibirsk. But seeing is believing. During the visit, I have been deeply impressed by your scientific research capabilities and the explorative atmosphere. I worked with a scientific and technological department for years. In this sense, we are colleagues. It always gives one great pleasure to meet colleagues.

Russia is a scientific and technological power in the world. Russian scientists have made outstanding contributions to the progress of human civilization. Lomonosov, Mendeleyev, Pavlov, Tsiolkovsky, Popov, among others, left their names in the world history of science and technology. Even today, Russia leads the world in many key scientific and technological areas.

The Science City of Novosibirsk is a scientific base known for its research strength. In both the basic sciences like mathematics, physics, biology, and chemistry, and applied sciences like comprehensive utilization of energy, environmental protection, and nuclear technology, you in Russia have produced a wealth of achievements in scientific research up to world standards, as well as a number of world-famous scientists such as Lavrentiev, Kantorovich, and Dubinin. It is rare for a city of only 1.7 million people to boast as many as about 100 research institutes for different purposes, 20 institutes of tertiary education, and tens of thousands of people specialized in scientific research.

The progress of human civilization has more and more convincingly proved that science and technology constitute a primary productive force and an important driving force for economic development and social progress. None of the achievements mankind has scored in understanding and taking advantage of nature would have been possible without scientific and technological advancement. Human wisdom is inexhaustible. Science and technology are a shining beacon of this wisdom. A great many scientists, one after another, have kept scaling new heights in science and technology after overcoming numerous obstacles through arduous efforts.

The 20th century is one full of unprecedentedly splendid achievements in science and technology and full development of scientific rationality. Never before has mankind produced as many scientific results and material wealth as in this century. The birth of the theory of relativity and the quantum theory early this century, the breakthrough in the semi-conductor technology in the 1950s, and the discovery of the double spiral structure of DNA have set off a round of geometrical development of science and technology in the world.

Since the middle of this century, major progress has been made in the studies of

Continued on page 27

IN THE FOOTSTEPS OF HUMBOLDT

Now Is the Time for South American Development

by Elisabeth Pascali

"On the one side, there is a grave danger that civilization is plunging into a Dark Age, that if the policies of the international monetary institutions are continued, many countries will suffer the same fate as Honduras, Nicaragua, Indonesia, or most parts of Africa. But, while I am absolutely clear on that danger, I also want to report to you that just in the last two weeks, something extraordinary has occurred: namely, that the countries of Eurasia are joining together in building the Eurasian Land-Bridge—the idea to integrate the Eurasian continent through infrastructure programs."[1]

This is the opening of a dramatic speech given on Dec. 2 by Helga Zepp-LaRouche, head of the Schiller Institute, at an event in Mexico City sponsored by the Ibero-American Solidarity Movement. The previous evening, Zepp-LaRouche had addressed precisely these issues, speaking at the headquarters of the Mexican Society of Geography and Statistics. In her speech, she traced out the history of the doomed policy of globalism and the hopeful re-emergence of the policies of transcontinental infrastructure development and defense of national economy. She stressed that now is the time that the nations of Ibero-America must again pick up the fight for the integration and development of their own continent.

Zepp-LaRouche was followed by a 15-minute commentary on her remarks by former Mexican President José López Portillo, who thanked her and her husband, economist Lyndon LaRouche, for their enthusiasm in their endeavor to "enlighten us as to what is happening in the world, as to what will happen, and as to what can be corrected."

Plans for the economic integration of Ibero-America have been discussed for more than a century. Zepp-LaRouche noted that at the entrance to the Geographical Society's headquarters, located in the historic district of Mexico City, stands a bust of Alexander Humboldt, who was a member of the society, which was founded in 1833. Humboldt was one of the first to propose connecting the three great river systems of South America, which he explored, into a continental transportation system.

Ruben Cota Meza/EIRNS

In the footsteps of Alexander von Humboldt: Former Mexican President José López Portillo (left), Schiller Institute president Helga Zepp-LaRouche, and EIR director of Ibero-American Intelligence Dennis Small, at a meeting of the Mexican Society of Geography and Statistics in Mexico City, Dec. 1.

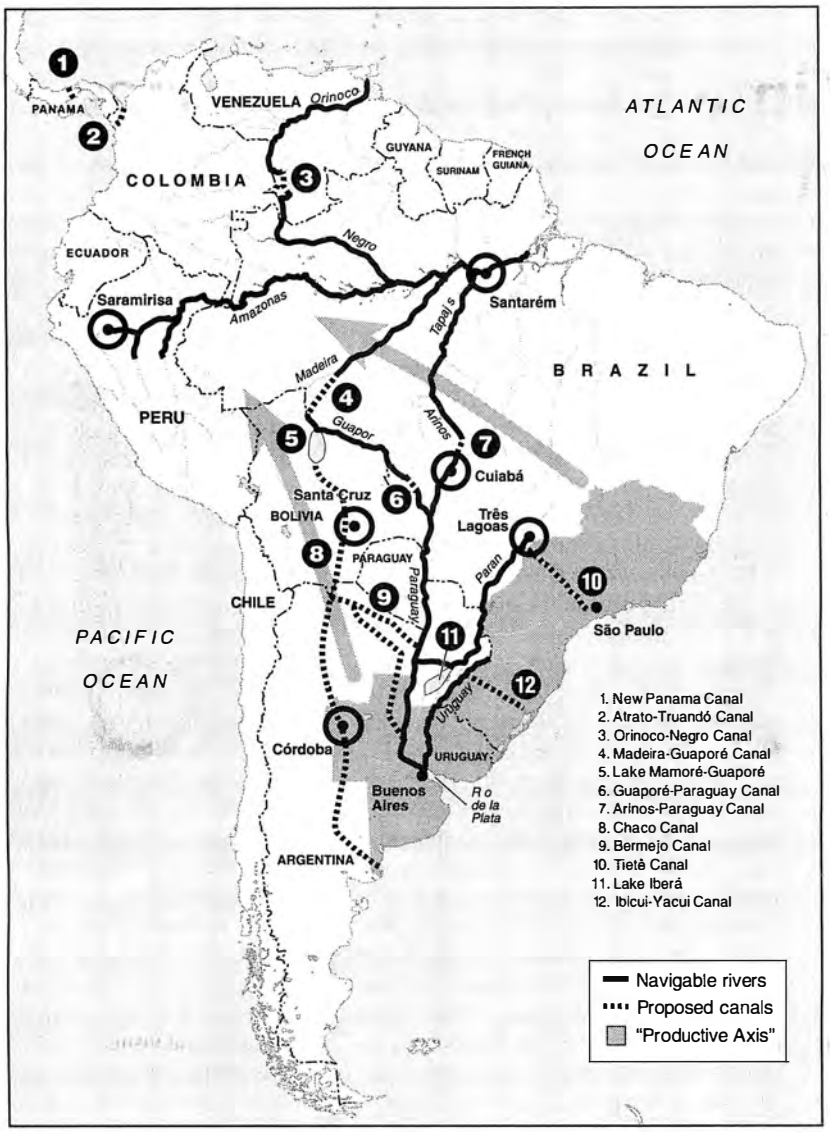
"I know that he would be very happy with what is happening in the world today because the dramatic changes which we see before us are a positive sign for humanity," she said. In this sense, she commented, her visit to Mexico follows "in the footsteps of Humboldt."

Tremendous Opportunity

Many institutions in most of the nations of Ibero-America, in fact, are thinking more closely about economic integration, and how to stop the horrors of economic collapse that have been caused by free-trade globalist policies and the international monetary conditionalities. Earlier this year, in August, Zepp-LaRouche visited Brazil, invited by several institutions including the presidential campaign of Dr. Eneas Carneiro.

In her speeches there, she stressed that now is the time in which "developing countries" must play an equal role to that of the industrialized countries. In South America, she said, the development of continent-wide infrastructure, "from north to south, from east to west, the building of waterways, of highways, of high-speed rails, as the center of opening up the country for industrial and agricultural development, is obvious"—and long overdue. Brazil and other nations should do this, she said, not for the extraction of raw materials, but because these transportation corridors can also become development corridors to uplift whole populations.

As to why this is important, Zepp-LaRouche noted, "Where does wealth come from? "*It comes from the development of the minds of the people.* Mr.



GREAT WATER PROJECTS TO INTEGRATE SOUTH AMERICA

A 6,000-mile water transportation system for Ibero-America would link up the three main watershed regions of South America—the Orinoco, Amazon, and Rio de la Plata river basins, with a series of canals. Plans for waterway and railway networks across the continent have been on the drawing boards since the 19th century.

LaRouche has put great emphasis on what he calls the *Machine-Tool Principle* [creating the capability for technology advances] because the concept of man in the image of God, creates an adequate hypothesis about the laws of creation, about the physical universe. If this hypothesis is adequate, it leads to a scientific discovery. . . ."

"In the coming period, everything which has to do with the IMF, with globalization, the World Bank, the World Trade Organization, will all vanish," she continued. "*But there must be people who have a well-thought-out plan of what to do in that moment of crisis, because that moment of crisis can be a moment of great danger—but it can also be a tremendous opportunity.*"[2]

The Schiller Institute has been promoting the integration and development of the South American continent since the 1980s, and in 1986, it issued a book-length proposal for the integration of the entire continent.[3] The authors point out that economic integration has a number of different facets. Most important, the Schiller Institute stressed, is the cultural commitment of the sovereign nations involved to create the conditions necessary for the continuous development of their populations.

The book summarizes the guidelines for this process:

(1) Physically integrating the region through construction of great infrastructural works, which, in turn, increase the economy's overall productivity.

(2) Reinvesting wealth generated by the economic process in order to maximize employment of labor power with the best possible technology and productivity.

(3) Establishing a protective tariff system which guarantees the development of regional industry to supply the maximum of the region's necessities.

(4) Applying state dirigism to create a currency and a credit system subordinate to the sovereign interests of the nations; that is, to facilitate the first three requisites and to punish usury and other forms of economic immorality.

There have been many attempts to create a transcontinental, and inter-continental, transportation grid for Ibero-America. As the Schiller Institute book, *The Integration of Ibero-America,* notes, "One of the most important integrationist initiatives which surged forth in the 1870s and 1880s, was the idea of building a continental railroad network which would link the continent from Tierra del Fuego to Mexico, and which would connect there with the great railroad system already existing in the United States."

Such a proposal was put forward in February 1890, at the Pan-American Conference in Washington, D.C., by Mexico's representative Matías Romero. Romero—who had been Benito Juárez's ambassador to Abraham Lincoln three decades before—achieved the passage

of a resolution favoring the building an intercontinental railroad or Pan-American railroad, using the railroad policy of his old friend Lincoln as a model. The conference set up a commission to study the project, and a few years later, the Commission on the Panamerican Railroad, chaired by José López Portillo y Rojas (the grandfather of the former Mexican President), released its final report. That 1890 report noted:

"Experience has everywhere shown that the development of a country's natural resources follows the establishment of rail communications. . . . Communications between the nations of the hemisphere would bring nothing other than development of the republics of the South, especially their interiors. . . . Statistics from the majority of these countries show that until now only the regions contiguous to the sea have been developed. . . . Such a railroad would help to exploit the territory now practically inaccessible and would contribute to the general wealth of the countries that it passes through."

Opening Up the Interior

More recently, Professor Vasco Azevedo Neto, a former Brazilian presidential candidate, has combined the plans for railroad and water routes into a proposal to open up the interior of Ibero-America along what he terms, "the path of least resistance." This idea, he says, was inspired by "the theories and forecasts of the polemical American politician and economist, Lyndon H. LaRouche." Professor Vasco's plan is to look for the paths of least resistance in the physical geography, which will lead to the greatest rates of economic development.

The main connections of the South American river systems which Professor Vasco calls the "Great Waterway," is shown in the accompanying map. Dennis Small, Ibero-American Editor for the *Executive Intelligence Review,* the political weekly magazine associated with LaRouche, described the river system in a Washington, D.C. conference of the Schiller Institute earlier this year.[4]

"There are two principal connection points that have to be developed," Small said. "One, where the Orinoco links up with the Amazon, which is in a region called the Casiquiare, at the headwaters of *both* river systems. This is one of the most fascinating geographical areas on the face of the Earth, because it has water that comes from underground springs, and flows in two opposite directions simultaneously."

What's required is a canal system to connect these two systems, and thereby make the entire area navigable. Further south, on the Amazon system, it can link up to the Paraná/Rio de la Plata system in the Guaporé rapids area, if canals are constructed.

Carrying out this development program would create an internal navigable waterway that is 9,800 kilometers long—about 6,000 miles. If you think back to the importance in America's industrial development of opening up the Ohio and the other river systems, Small said, it gives you and idea of how crucial such a program would be for South America.

The Motor for Development

The shaded area in the map—southern Brazil, Uruguay, and northern Argentina—is what the Schiller Institute has called the "Productive Axis" of South America. It is only 12 percent of the total land area of Ibero-America, but it has 26 percent of the population, 40 percent of the electricity production of the continent, and 44 percent of the manufacturing. "This is the most economically dense region, and it has to be the motor which spreads development—technology and labor-force development—throughout the interior of the continent, through not only this Great Waterway, but also through an integrated continental railroad system," Small said. He pointed out that the railroad has the crucial capability—unlike the Waterway, which can't go over the Andes Mountains—of linking South America up with the Pacific Basin and the Eurasian Land-Bridge.

As for the existing railroads of Ibero-America, Small said, they are "relics of colonialism." The railroad density (kilometers of rail per square kilometer of land area) is only one-sixth that of the United States, and one-thirteenth that of France! To make it worse, there are six different gauges in Ibero-America, such that, the existing rail systems, cannot interlink the traffic of one country to another.

"This was an intentional colonial policy," Small said, "to have rail lines running only from the mines, to the ports, for export of raw materials."

The Grande Carajás Project

A different, non-colonial approach to development must include, along with transportation, an investment in the productive industry of nations. The original conception behind the Grande Carajás iron mining project in Brazil is an example of the potential that exists to use the raw materials of a nation as the starting point to create whole new areas of development. It is also an example of how such potential has been sabotaged by the policies of the International Monetary Fund.

The Carajás iron mine[5] is located a little more than 300 miles south of the equator, in the middle of the Amazon rain forest, but in hills 2,000 feet above sea-level. Its iron deposit was discovered in 1967, by a Brazilian engineer who was working for U.S. Steel. The man was engaged in helicopter reconnaissance work searching for manganese, when he noticed a range of reddish, denuded hills amid solid jungle overgrowth, an indication of the presence of some kind of mineral deposits. Telegraph records demonstrate that the engineer's reports that he found sizable deposits of very pure iron ore were repeatedly and insistently dismissed by U.S. Steel officials in the United States. The engineer was told, "Forget the iron; we are looking for manganese!"

Subsequently, the Brazilian government re-purchased all of the rights to the area from U.S. Steel. The Serra dos Carajás, composed of two adjacent ranges, has an estimated 18 billion tons of iron ore-enough to supply the entire world's current demand for at least 25 years. The mineral has an average purity of 66.8 percent, compared to average purities of 20 to 25 percent in almost all iron mines in the United States today.

In many locations, the iron ore reaches 70 percent purity—the highest technically possible given the molecular structure of the substance Fe_2O_3—and can literally be pulled off the mine wall in powder form with one's own hand.

The Brazilian government gave the primary responsibility for the project's execution to the state mining company, Companhia Vale do Rio Doce (CVRD). The original plans conceived the Grande Carajás project as only the first step in Brazil's conquest of the Amazon. There were plans to have a city of 20,000 people at Carajás, along with a railroad which would open up an area the size of Italy in the Amazon jungle for agro-industrial settlement.

But under one pro-IMF government after another, Brazil ended up orienting the Grande Carajás project to merely produce raw materials for export, and to thereby generate foreign exchange with which to pay off Brazil's gigantic foreign debt—the largest in the world. Then in 1997, CVRD itself was privatized, to a private consortium financed by the international speculator George Soros—for the equivalent of one month's worth of national interest payments!

However, as Zepp-LaRouche stressed in her recent interventions in Brazil and Mexico—among others: As the system of globalism collapses, the nations of Ibero-America must be ready to cooperate and carry on with these development and integration projects.

The plans for integration of the continent are on the drawing boards. The question is whether the Ibero-American nations will take up the development banner, and move forward, along with the Eurasian countries that are turning the Eurasian Land-Bridge into reality.

Notes

1. Helga Zepp-LaRouche's speech, "We Have a Golden Opportunity to Save Civilization from a New Dark Age," appears in the Dec. 11, 1998, issue of *Executive Intelligence Review*," p. 34.
2. Zepp-LaRouche's Brazilian speech appears in *Executive Intelligence Review*," Aug. 28, 1998, p. 33.
3. Instituto Schiller, 1986. *La integración iberoamericana: Cien milliones de nuevos empleos para el ano 2000* (New York: New Benjamin Franklin House).
4. Dennis Small, "Brazil Is Likely to Be the Next 'Big One,' " *Executive Intelligence Review*, Sept. 25, 1998, p. 31.
5. "Carajás: First Step Toward an Amazon Industrialization Drive," *Executive Intelligence Review*, Oct. 26, 1982, p. 16.

Chinese President Speaks on Science

Continued from page 23

atomic energy, space technology, microelectronics, information technology, bioengineering, and new materials, which has greatly increased the human cognitive power of nature and society. Knowledge economy has started to take shape, and new industries have kept emerging. Mankind is experiencing a global scientific and technological revolution.

The Frontiers of Science

Recently, there have been some major new orientational developments in the advancement of science and technology in the world. The focus of research in the science of matters has been shifted to the study of the properties of matter and their interaction under extreme conditions, thus laying a new ground for the creation of new materials, new energy, and clean and efficient technologies. Bioengineering, which is centered on molecular biology, promises a fresh major breakthrough, which will open up a completely new prospect for agriculture, medicine, and human health. . . . Space science has helped people deepen their understanding of the origin of space and its evolution, providing a new panoramic picture of the structure of different forms of matter and their interaction. Geo-science has increasingly become a multidiscipline science, enabling man to acquire new capabilities in the exploration, protection, and rational utilization of natural resources and ecological environment.

Scientific and technological development, with its overlapping, frontier, and diversified nature and the ever-faster production, dissemination, and application of scientific and technological knowledge have given rise to enormous socio-economic progress, promising a bright future for human civilization.

The new scientific and technological revolution has presented people of all countries with precious development opportunities and also serious challenges. A country or nation would lag behind and land itself in an extremely passive position, unless it were to closely keep abreast with scientific and technological progress and upgrade its scientific and technological level in the light of its national development texture.

The Importance of Education

In order to meet the challenge of rapid scientific and technological progress and the fast-rising knowledge economy, we must keep on creating and innovating. Creativity is the soul of a nation and an inexhaustible source of a country's prosperity. The key to creation and innovation lies in human resources, whose development depends on education. Only a well-developed education can sustain scientific and technological progress and economic development. Scientific and technological strength and the educational level of a nation have always been an important yardstick for measuring the overall national strength and the civilization of a society. Like indispensable wheels, they propel a country to prosperity.

China is one of the cradles of world civilization. Its education and science both have a glorious history. The ancient Chinese science and technology symbolized by the four famous inventions—paper-making, gunpowder, printing, and the compass—had once tremendously influenced the development process of human civilization and profoundly changed the face of world civilization.

Since the founding of New China, especially over the past 20 years of reform and opening-up, the Chinese government has always attached great importance to the development of science, technology, and education. The well-known conclusion that "science and technology constitute a primary productive force," drawn by Comrade Deng Xiaoping, is now becoming an important idea guiding China's development. We have given a prominent position to the strategy of economic development through science-technology and education, and a sustainable development strategy, when drawing up the blueprint for the modernization drive.

Creativity is the soul of a nation and an inexhaustible source of a country's prosperity.

Recently we have decided that the Chinese Academy of Sciences should take the lead in introducing a pilot program of instituting a national knowledge innovation system. That is, to identify new objectives of scientific and technological development, readjust the existing operational mechanism, strive for more and greater scientific and technological innovations, and put in place an innovation system for China in view of the need of a development strategy for China of the next century and the prospects of the world frontier sciences.

In the 21st century, we will achieve a take-off in science and education so that China's modernization drive will be able to advance steadily along the path of development, through scientific and technological progress and through improved quality of human resources. . . .

SCIENCE AND LIFE

A Dialogue on the Importance of Keeping People in a Healthy, Unbalanced State

Illustrations by Alan Yue

This dialogue considers some crucial paradoxes raised by the discovery of the so-called mitogenetic or biophoton radiation of living organisms, by the great Russian biologist Alexander Gurwitsch. At the same time, it intends to provoke reflection on one of the unique ideas that Lyndon LaRouche has contributed to science in his concept of "nonlinearity in the small."[1]

by Dr. Jonathan Tennenbaum

PART 1: PARMENIDES REVISITED

Two leading biologists, Dr. Lebensfroh and Professor Todtkopf,[2] were recently arguing about the nature of living processes. Although the two have opposite opinions, they share a common, underlying error of axiomatic assumption, which is pervasive among even the best scientific professionals today.

Todtkopf: So, you keep up with this "vitalist" obsession of yours, that there is something unique about living processes. How can you reject the fundamental accomplishment of modern biology?

Lebensfroh: What you call "biology" has long since degenerated into blatant reductionism and mechanicism, losing sight of the real objective, which is "life." To me, biology should be defined as the study of exactly *those* aspects of living processes, which distinguish them *absolutely* from nonliving processes.

Todtkopf: I say there are no such differences. A living organism is nothing but a very complex aggregate of molecules, interacting and combining with each other according to the known laws of chemistry and physics. Everyone knows that biology today is just a specialized branch of physical chemistry. The triumph of molecular biology is a great victory of science over naive superstition and metaphysics. For centuries, unscientific people clung to the romantic idea, that some sort of "life force" or "living fluid" inhabits the tissue of animals and plants and lends them their "living" quality. But nobody ever found this living force. So it was a great breakthrough, when chemists demonstrated that living organisms are composed of exactly the same atomic elements and particles that we find in the inanimate world, in the atmosphere, in rocks and so forth. Looking for anything more is like grasping for ghosts in thin air. But fanatics continue to defend the notion of a "life force" up to this very day.

I remember the uproar which was created when Justus Liebig published his book *Chemistry and its Applications to Agriculture and Physiology,* in 1840, showing that living tissue is composed nearly entirely of the simple elements hydrogen, oxygen, carbon, and nitrogen, and that plants can grow on inorganic material alone. Liebig's proposal to introduce mineral and chemical fertilizers into agriculture met fanatical resistance, even among scientists, who insisted that the nutrition of plants must involve organic material in some essential way. Even today, there is a big market for food grown with "organic fertilizers," and many people believe that plants grown with mineral fertilizers are somehow different and even poisonous to the health. But these ideas have been refuted long since. There is no special material in living organisms, the atoms are exactly the same there as in this dirty piece of rock.

Lebensfroh: But in living tissue the atoms are organized and transformed into complex organic molecules, like proteins and DNA, for example, which are not found in the inorganic world. Only living processes do that.

Todtkopf: People like you didn't want to believe it, when the great chemist Friedrich Woehler succeeded in *artificially* synthesizing the organic substance *urea* from oxygen, hydrogen, carbon, and nitrogen in the laboratory. That was 1828. Until then, many biologists and chemists believed that living organisms had their own, fundamentally different chemistry, and that the most important molecules composing living tissue could never be produced outside living tissue. The famous chemist J.J. Berzelius even put forward the "vis vitalis" hypothesis, according to which the characteristic difference between living and nonliving systems lay exactly in the former's supposedly unique powers of chemical synthesis. This idea was the original basis for the division between "organic" and "inorganic" chemistry, which turned out to be just conventional and not fundamental. After Woehler, countless other organic molecules were synthesized, and today, we can make amino acids, small proteins (peptides), and pieces of DNA in the laboratory with no trouble. So, there is no special chemistry and no magical synthetic powers of living organisms.

Lebensfroh: Aren't you cheating with that argument? You left out the fact, that living human beings—chemists—carried out those laboratory syntheses. So they are still products of living processes, even if the reactions that produce them occur in a test tube. The organic molecules would never arise by themselves, without human intervention.

Notes

1. Gurwitsch's work is described in detail in a two-part feature "Alexander Gurwitsch and the Concept of the Biological Field," written by his student, Michael Lipkind, which appeared in the Summer and Fall 1998 issues of *21st Century*. Lyndon LaRouche's "Remarks on Gurwitsch's Method" appears also in two parts, in the same issues of *21st Century*. In addition, LaRouche's science policy statement, "The Reciprocity of Extremes: The Astrophysics of Gurwitsch Radiation," appears in the Fall 1998 issue.
2. In German, Lebensfroh is "Light-hearted," while Todtkopf translates as "Dead-head."

Todtkopf: Not true. Researchers have demonstrated in laboratory experiments, that amino acids—the building-blocks of proteins-—can be generated by electric discharges in a gas similar to the Earth's original atmosphere. The Nobel Prize-winning chemist Manfred Eigen has shown, that in a "soup" of chemicals, more and more complex molecules can evolve from simpler ones in a purely spontaneous manner, through a kind of natural selection process among competing chemical reaction-cycles. Given enough time, I am sure all the complex biomolecules would eventually arise in such a self-organizing "chemical soup." Eigen proposes that the first primitive living organisms actually evolved in this way, and I believe him. It was a gradual process, and there was never a definite point when you suddenly had "life," and before just a lot of reactions.

Lebensfroh: You mean to say, that if your mother had only been 5 percent pregnant and if you were 95 percent dead, you would still be speaking to me now?

Todtkopf: Sometimes I feel that way.

Lebensfroh: But, seriously, you cannot deny that living organisms behave completely differently from non-living matter?!

Todtkopf: This is just a matter of degree of complexity. Naturally, the more complex a system becomes, the more circus tricks it can perform. But in principle, every chemical process going on in a living organism could be carried out just as well in a test tube. We are already doing DNA synthesis and other sorts of enzymatic reactions that way. It's just when you put all those molecules and reaction processes together, that you get the effect of life.

Lebensfroh: What about *growth?* Only living processes grow in a self-similar, exponential way. Whatever you say about the origin of living processes, the *power of growth* distinguishes them absolutely from non-living matter.

Todtkopf: Really? Crystals can grow too, can't they? Haven't you watched how sugar or salt crystals grow in a water solution? Would you say those growing crystals are alive?

Lebensfroh: No,no, wait a minute. Uh, crystals don't grow in an exponential way, but actually more like an arithmetic or rather cubic series, as additional layers are added on, surface by surface.

Todtkopf: And what do you say about a *chemical chain reaction,* as we find in the detonation processes in various explosives? Furthermore, in the 1920s, the Russian chemist Semionov discovered the phenomenon of "branched chain reactions," in which a population of enzymatic molecules grows exponentially, by catalyzing the synthesis of identical molecules in a mixture of reactants. These "autocatalytic" processes display exactly the same growth-curve characteristics, as cultures of bacteria and other living organisms.

Lebensfroh: But this only works until the mixture of reactants is used up. After that the process stops, doesn't it?

Todtkopf: Don't living organisms also stop, when their source of nutrition is exhausted? After all, living organisms, like bacteria, never actually grow exponentially. Their growth curve is always an "S-curve," as growth slows when the bacterial population has reached a maximum density, where the available sources of nutrition become marginalized and the culture reaches an equilibrium or stationary state. And such S-

On the Fate of Gurwitsch's Work

The discovery of so-called "mitogenetic radiation" by the Russian biologist Alexander Gurwitsch, as a by-product of Gurwitsch's investigations into the higher principles of organization of living processes, was regarded by many leading scientists in the 1920s and early 1930s as one of the most far-reaching experimental discoveries in modern science. Among those was V.I. Vernadsky, a personal friend of Gurwitsch from the beginning of his researches at the Crimean town of Simferopol in 1918.

Alexander Gavrilovich Gurwitsch (1874-1954)

Gurwitsch's decisive experiments in 1923, established that (1) all living tissue is a source of sustained, though highly variable and (in scalar terms) *extremely weak* radiation in the ultraviolet range of the light spectrum; (2) the process of cell division (mitosis) can be triggered by the absorption of no more than a *single photon* of such light by a suitably disposed cell; and (3) the existence and function of such "mitogenetic radiation" is intimately connected with the manner in which all local processes in a living organism—for example, on the cellular, molecular and even atomic scales—are subordinated to a principle of organization unique to the living organism as a whole. By using mitogenetic radiation as a crucial experimental method in embryology, physiology, the study of the nervous system and other areas, Gurwitsch and his collaborators made one remarkable discovery after another, continuing through Gurwitsch's death in 1954.

Starting no later than the end of the 1920s, systematic operations were launched to "kill" the new area of research. These included a widely publicized hatchet-job done on behalf of the Rockefeller Foundation by one A. Hollaender. By the end of the 1930s, Gurwitsch's scientific reputation in Western countries had been significantly undermined, only to be virtually buried under the onslaught of ultra-reductionist currents of molecular biology after World War II. While the main lines of Gurwitsch's work continued to be pursued in the Soviet Union—including in military-related domains—the efforts of Hollaender et al. established the "consensus opinion" in the West, that Gurwitsch's radiation did not exist; or in case it did exist, that it had no scientific importance. With the rapid overall decline in the quality of science in the

curves are typical of thousands of autocatalytic chemical reactions, which we can make in a laboratory. So in terms of the growth curve, you can't tell the difference between the growth of various chemical species in an auto-catalytic, branched chain reaction, and a population of bacteria which grows in the same way.

Lebensfroh: But what about the population of the human species? The human population has grown exponentially over history.

Todtkopf: I don't think that can continue indefinitely. After all, resources are limited. But even if human multiplication could continue without limit, you mean to say that only human beings are living organisms, and animals and plants are not?

Lebensfroh: No. The growth of the human population, and its impact on the biosphere in terms of a multiplication of domesticated plant and animal species, demonstrates that the *totality* of living material on the Earth, taken as a whole—what Vernadsky called the biosphere, including human beings—the biosphere has the potential for *unlimited growth* in the Universe. Actually, this was the directionality of evolution even before human culture emerged. So we can say, that living organisms are uniquely characterized by the *potential* for exponential growth, as part of the growing biosphere.

Todtkopf: Well, then, from your rather involuted argument you will have to recognize countless *inorganic* processes on the Earth as "living," if they are connected with the growth of the biosphere in any way, won't you? After all, the combustion of oil, or the production of steel, has increased exponentially with the expansion of human population and its economy. So would you include combustion or steel production as living processes?

Lebensfroh: Of course not. You are just twisting my argument into nonsensical shape.

Todtkopf: Then where do the inorganic processes leave off, and the "living" process begin? You claim there is a categorical, absolute distinction between the two. Would you say that the oxidation of glucose in cells is a living or nonliving process? It's really just a form of combustion isn't it, burning sugar for energy.

Lebensfroh: This is just a trick of yours, to rip an individual chemical process out of the organic context of the living process of which it is a part. In fact, the unique characteristic of living organisms is their indivisible unity or "wholeness," which means that all processes going on in an organism are interconnected and subordinated to a single overall principle, and that all react together as a whole—rather than an assembly of parts—to every change in the organism's environment. No mere mechanical or other non-living physical system has such characteristics.

Todtkopf: Wrong again. Modern quantum physics has gone far ahead of you, and identified what are called "macroscopic coherent states" in *non-living matter*—states you would be forced to admit have every bit of that quality of "one-ness" you ascribe to living organisms. Even the wave-front of a light wave displays this quality, as Fresnel already demonstrated in his analysis of the diffraction of a light-beam at a sharp edge: When part of a light-wave encounters an obstacle, the entire

Soviet Union from the 1960s and especially the 1970s on, the focus on the fundamental implications of Gurwitsch's workwas nearly lost there, too.

It was only in the mid-1970s that Gurwitsch's work began to be revived in a serious way, with the work of Fritz Popp and his collaborators in Germany and other countries. From 1985 on, Lyndon LaRouche personally and his collaborators have played a crucial, indispensable role in keeping work in this and related areas alive internationally. In every case that has been examined so far, the results of Gurwitsch's laboratory have been confirmed. In the meantime, technological developments make it possible to design new species of experiments which would not have been possible in Gurwitsch's time.

The Threat to British Eugenics

In retrospect, it is obvious that a major motivation for burying Gurwitsch's work, was that it threatened to derail the British plans, notably supported by the Harrimans, Rockefellers, and others, to establish "race science" and eugenics as "authoritative scientific doctrines." This program was resumed immediately after the war, and took the included form of a massive promotion of radical-mechanistic, reductionist forms of molecular biology and genetics, which had already begun to be developed by Max Delbrueck and others in the middle 1930s, with the support of the Rockefeller Foundation's Warren Weaver. Of course, these operations went hand-in-hand with the promotion of behaviorist psychology, mechanistic theories of nerve function (Hodgkin-Huxley, John von Neumann, Norbert Wiener, and so on), the work of von Neumann and others on formal logic, "artificial intelligence," "self-reproducing machines," "information theory" and so on and so forth. The British side, often clothed in "holistic" trappings, included the Huxleys, Joseph Needham, J.S. Haldane, Waddington, Bernal, and, of course, Russell, among others. The Cambridge side of the British elite were predominantly biologists, following in the putative footsteps of Aristotle himself. Of course, the so-called "biologism" of Haeckel et al. was an important current flowing into the Nazi movement, and into today's New Age and green movements.

I personally had the occasion to visit Hollaender in his New York office together with Fritz Popp around 1985, not long before Hollaender's death at the age of more than 90. Hollaender admitted having been deployed by the Rockefeller Foundation to Russia with the sole purpose to "investigate" Gurwitsch and his laboratory, bringing back the story that Gurwitsch's experimental technique was allegedly "sloppy" and his results "unreliable." (Hollaender subsequently carried out and published in 1937 his own botched series of experiments, allegedly failing to discover any evidence of Gurwitsch's radiation.) Confronted with Popp's detailed measurements of mitogenetic radiation using modern photomultiplier instruments, Hollaender admitted, without blinking an eyelash, that he "had always suspected Gurwitsch had been right."

—Jonathan Tennenbaum

wave-front "reacts," and the direction of propagation is changed. Within scale-lengths of the order of a single wavelength of light, the light wave behaves as an indivisible whole.

Beginning in the early 1920s, entirely analogous characteristics were demonstrated for beams of electrons. Modern quantum physics teaches us, that even a single electron involves a process distributed over a large region of space, and which "feels" all the events occurring within that space. Furthermore, we today have countless experimental proofs, that there is no such thing as a truly isolated, independent particle, atom or molecule. Rather, in a certain sense each particle in the Universe "knows" and reacts to what is happening with every other one, without having to be informed by any sort of signal! Our lasers, superconductors, and even the semiconductor devices which are the basis of today's computers and communications systems, are all based on that principle. In such devices, huge numbers of atoms behave as if they constituted a single coherent entity. The fact that we can demonstrate this sort of "holistic" behavior in so-called nonliving systems, has been a major breakthrough, demystifying the characteristics of living organisms and demonstrating, once again, that there is no categorical distinction between living and non-living processes.

Lebensfroh: You are bluffing. You are ignoring the crucial property of living organisms, which is their ability to *reproduce themselves,* based in the unique process of mitosis or cell division. No reductionist or mechanistic theory could possibly describe such a self-reproducing process.

Todtkopf: Evidently you are not familiar with the work of John von Neumann on *self-reproducing machines.* Although such machines have not actually been built yet, von Neumann proved their feasibility in principle long ago, and he even worked out how such machines would have to be programmed. Essentially, a self-reproducing machine would consist of a complex of computer-controlled, automated industrial processing-units and robots, all directed by a central computer. The robots gather raw materials from the surrounding area and feed them into the industrial process-units, which in turn produce materials and parts to match those from which the central computer, robots and industrial process-units themselves were constructed. As the final step, the central computer directs the assembly of those parts into a second copy of itself and its robots and industrial processing units. Obviously, such a machine would have to be extremely complex, and indeed, this is the fundamental point that John von Neumann and others have stressed—that there is a lower limit to the necessary, minimum complexity of a self-reproducing machine. This explains why qualitatively new types of phenomena occur when systems become as complex as cells. So a living cell is just an extremely complex kind of self-reproducing machine, with a bit of holism thrown in, if you want.

Lebensfroh: You mean to say, you are a von Neumann clone.

Todtkopf: No doubt about it. That's where all of us modern biologists come from.

Part 2: Help from Nick

Lebensfroh felt frustrated and a bit depressed after his encounter with Prof. Todtkopf. He was sure he had been right, and Todtkopf wrong, when he insisted that living processes could not be reduced to the same physics as nonliving processes. But in spite of this, Todtkopf seemed to have come out ahead in the debate. Todtkopf's arguments reminded him of prosecutors who can "prove" or "disprove" anything, by a selective arrangement of supposedly unassailable, "hard facts." Lebensfroh had tried to defend life, and lost his case. It wasn't any particular argument, but the *whole debate* that had somehow missed the point. Lebensfroh felt embarrassed, like someone who had lost his wallet to a pickpocket.

Returning home, Lebensfroh sank deep into his armchair. He went through the discussion with Todtkopf again in his mind. Where was the mistake? Lebensfroh had presented a series of properties *A, B, C, D . . .*, each one of which he considered to be a unique and exclusive property of living processes: the synthesis of complex organic molecules, exponential growth, self-replication, "wholeness," and so forth. One after the other, Todtkopf returned the argument, by presenting examples of nonliving processes which seemed to have the same properties, and maybe even all of the properties Lebensfroh had come up with. Lebensfroh was dismayed. What he thought he had understood very well before the argument started—namely the unique nature of life—now seemed to have evaporated into something intangible and elusive, even in his own mind.

Suddenly he had a new thought. He recognized it came from something he had read long ago by Cardinal Nicholas of Cusa, concerning the nature of the circle. The thought was: If someone would specify any set of points *A, B, C, D . . .* on the circumference of a circle, would that determine the circle as the curve passing through those points? Well, obviously not; someone else could just connect the points by *straight lines,* getting a polygon, which is not the same as the circle. No number of points, so supplied, could ever suffice to distinguish the circle from a mere polygon. What, then, is the characteristic distinction of the circle?

Lebensfroh's gloom and frustration disappeared, like the popping of a bubble. In his mind's eye, Lebensfroh caught a glance of the old cardinal's face, smiling at him. Lebensfroh smiled, too. "Thanks, Nick," he heard himself say.

The next day, Lebensfroh met Prof. Todtkopf again.

Todtkopf: Well, I hope you have given up your silly idea after our last conversation.

Lebensfroh: Indeed. I will never again lose sight of the false, lying nature of so-called "scientific facts."

Todtkopf (shocked): What do you mean!? Facts never lie. Facts are the very foundation and essence of truth.

Lebensfroh: Wrong. I say, truth lies entirely outside, above and apart from mere "facts"; and no single fact, nor any collection of facts, however comprehensive, could ever represent truth. Only ideas, not facts, can represent truth.

Todtkopf: Are you crazy?

Lebensfroh: I will show you. See how I draw this circle, and now I mark points *A, B, C, D,* etc. on it, which represent what you call "facts"—

Todtkopf: Don't talk to me about geometry. I am a biologist. I don't go there!

Lebensfroh: The problem is, the conception I want you to understand, cannot be communicated without a certain type of metaphor—

Todtkopf: I am a scientist, not a poet.

Lebensfroh: Well, I tell you it is *absolutely impossible* to grasp what a living process is, without metaphor. Because there is an ordering of ideas in science, and the conception of "living process" is a strictly *higher type* than any conception which can be communicated in a linear way. This would be obvious to you if you had worked through Gauss's determination of the orbit of Ceres, for example.[2] The nature of living processes, and the absolute, "strong" gap separating them from all non-living processes, lies in the characteristics of *change* manifested in the virtually infinitesimally small.

Todtkopf: I have no idea what you mean.

Lebensfroh: Well, I see we'll have to approach this through an example. I have it! Let's look at a unique case, which poses the relevant paradoxes in the strongest form: a physical economy, which is a very special sort of living process.

Todtkopf: What do you mean by "physical economy"? I remember reading something about that.

Lebensfroh: I mean the physical process by which a human population reproduces the material conditions for its continuing existence, at ever higher levels of potential population density.

Todtkopf: So it's more than just the living population and its immediate activity, but also the physical processes in mining and industry, which deal with inorganic materials, as well as things like farming?

Lebensfroh: Of course. Physical economy subsumes the processes of agricultural, mining and industrial production; distribution and consumption of goods; housing, education, and health services; cultural activities, scientific research, administrative and related activity and so on—everything necessary for the maintenance and development of human society from one generation to the next. In a sense, all these things form the tissue and organs of the physical economy as a coherent living entity.

Todtkopf: Ha! Now I have caught you in a contradiction! Just a moment ago you restated your old thesis, that there is a categorical distinction between living and nonliving processes, true?

Lebensfroh: True.

Todtkopf: And according to that you would distinguish between living and nonliving matter, wouldn't you?

Lebensfroh: Yes.

Todtkopf: Then tell me this. A piece of rock sitting somewhere in a mountain, is that living or nonliving material?

Lebensfroh: Nonliving, of course.

Todtkopf: And when that same rock is mined, and the ore is transported to a factory, and metal is produced, and that metal is worked up into parts, and the parts assembled into a machine, and that machine is integrated into the production process—would you not say, that the material of the rock has become part of the physical economy?

Lebensfroh: Yes.

Todtkopf: So then, if the physical economy is a living process, then the material which constitutes it must be living, must it not?

Lebensfroh: (hesitating) Well, I guess so.

Todtkopf: Then one and the same material is both living and nonliving, or else you will have to tell me at what point the rock, or ore, or metal, or machine, became "living," in your sense!

[Lebensfroh realized he was about to fall into the same trap, as he had done in his earlier debate with Todtkopf. Focussing on his happy idea about the circle, he recovered quickly and continued.]

Lebensfroh: Exactly. That is just the point. We are dealing with a multiply connected manifold.

Todtkopf: There you go again with your mathematics! Tell me plainly now: do you or do you not regard the machines in a factory as being *living,* in virtue of their being integrated as parts of the "tissue" of the physical economy, which you call a living process?

Lebensfroh: In a sense, absolutely, yes. But the "living" aspect of these things does not lie in the things themselves as isolated entities, but in the characteristics of the process of *change* in which they actively participate. And the chief characteristic of change, which defines a physical economy as *living* (as opposed to pathological, dying states of an economy), is *scientific and technological progress.* That progress takes the form of an incessant series of "pulses" or "shocks" of *change in the organization of production*—shocks which originate in fundamental scientific discoveries of principle, and propagate, like waves, throughout the tissue of the economy. Those pulses or shocks reflect the action of a higher geometry—one characterized by human creative reason—upon the ensemble of lower geometries composing the tissue of the physical economy.

Todtkopf: You mean to say, without those pulses, the tissue of the economy would degenerate and the economy would "die"?

Lebensfroh: Exactly. And I am sure that something analogous must occur in living processes generally, and on another level, in the creative processes of the mind itself. The great biologist Alexander Gurwitsch had some appreciation of this.

Todtkopf: What you say is amazing.

Lebensfroh: Not really. Imagine how stupid you would be right now, if Nicholas of Cusa had not helped me get your mind moving.

Part 3: Higher and Lower States

At the end of this discussion, Prof. Todtkopf was amazed and a bit overwhelmed by the conception Lebensfroh came up with, that physical economy might provide the key to understanding living processes in general. But later, as he thought back on the conversation, his admiration turned to suspicion, then irritation, and finally rage. The more he thought about it, the more ridiculous it seemed to him to mix up economics and biology as Lebensfroh had done, comparing an economy to a living cell, for example. Todtkopf's teachers had taught him to beware of sweeping analogies, which might excite our fantasy, but undermine the objectivity that is essential to professional scientific work. Todtkopf saw himself admonishing an audience of his colleagues: "In science the first step is to *define your terms;* and once you have done that, you have to stick to the definitions. If you start to play with metaphors and analogies, as Lebensfroh loves to do, then you can make anything into anything, as if you would say: the solar system is a living process, the galaxy is a living process, an atom is a living process, *everything* is a living process! Then we would all feel happy, like Dr. Lebensfroh. Absurd! By throwing words around like that, we accomplish nothing of any substance."

Lebensfroh has to be cut down to size, thought Todtkopf. He should stop acting as if he were superior to us empiricists, just because he has a creative mind. I'll give him a lesson on what science is all about. He started lecturing again:

"Science is based on empirical fact. That means observing and investigating the real objects in the world around us. To be able to arrange the facts, and to correlate facts in order to adduce general laws, you need to establish a division of the sciences. The sciences are divided according to the different kinds of objects you study. So, biology studies the living organisms which are divided into plant and animal. To determine what a living process is, you start concretely, by studying this specific plant, that specific animal. Nothing to do with economics or anything like that. You keep studying those plants and animals and then you correlate your observations and measurements and draw general conclusions.

So, by painstaking investigations, molecular biologists discovered the common molecular basis of living organisms—the amino acids and proteins, the genetic code and so forth. Step by step, we unravelled the mechanisms and we discovered that in each case we examine carefully, we find everything occurs according to the known laws of physics and chemistry---laws verified in hundreds of thousands of laboratory experiments. At least, no one in academia dares refute us. The wispy dreams of the vitalists, have given way to piles of hard facts. This is the triumph of science, the triumph of Aristotle, the first biologist and systems analyst!

"So don't ever forget, Lebensfroh: We empiricists are the ones who do the real work. We know what functions and what doesn't function in the real world. Don't stand there and try to tell us how we should do things!" Professor Todtkopf was so preoccupied, that he emptied his coffee cup onto his trousers.

The next day Todtkopf sought out Dr. Lebensfroh.

Todtkopf: Our conversation last week was fun, Dr. Lebensfroh. But speaking as a professional scientist, I must say, it was a waste of time.

Lebensfroh (taken aback): Why that?

Todtkopf: You presented not a single solid scientific fact, but only wild, irrelevant analogies to economics and so forth. I was taken in for a moment, but now no more.

Lebensfroh: Oh, oh, I see you have decayed into your lower state!

Todtkopf: Lower state? Decayed?

Lebensfroh: Well you know, according to modern physics we find that atoms and molecules can exist in different modes or states, which form a discrete series or spectrum that is characteristic for the species of atom or molecule involved.

Todtkopf: Every chemistry student knows that.

Lebensfroh: In the so-called ground states or lower-energy states, atoms and molecules are typically inactive and inert. But if we irradiate them with photons of the right wavelength, for example, we can raise them into a higher-energy, excited state. They become highly reactive, they begin to emit radiation, they are more lively and interesting in every way. We can get lasing and all sorts of wonderful things to happen.

Todtkopf: And?

Lebensfroh: But if they are left to themselves, and taken out of the special environment we have created, the atoms and molecules tend to decay back to their lower-energy states, and become lazy and boring again. So it is with **people,** too.

Todtkopf: There you go again with your analogies and metaphors! What does that have to do with me?

Lebensfroh: Because last week at the end of our discussion I had pulled you up to an excited state for a while and now you seem to have slipped back down. The difference is elementary and very easy to observe, when one knows what to look for. People in higher (creative) states of mind think of the Universe in terms of *change,* while in your lower state, you think of it in terms of arrangements of objects.

Todtkopf: What difference does that make? Thinking is thinking.

Lebensfroh: Not so. If you were to stay in your present state, you would be incapable of making any fundamental discovery.

Todtkopf: How do you know? I can look through a microscope as well as you!

Lebensfroh: Maybe even better than me, but you won't *discover* anything. Because a fundamental discovery is not the discovery of some property of an object, but a *change* in the characteristics of our own mental processes, a change in the way we *think* about the Universe as a whole. It occurs entirely inside the mind. And that is the beginning of actually changing the Universe itself. But it can't happen if your mind is in the deadened state, typified by a fixation on objects or object-like images.

Todtkopf: Challenge me. I will show you you're wrong.

Lebensfroh: Fine. The other day you asserted molecular biology had for the first time identified the chemical basis for living processes?

Todtkopf: Yes, of course.

Lebensfroh: Then tell me, what is the difference between a living cell, and the same cell immediately after it has died? The molecules stay the same. Even many reactions keep going for a while, as they might in the non-living environment of a test tube.

Todtkopf: Um. . .Uh. . . Well, eventually the normal processes stop and the cell disintegrates. You can see this in a microscope.

Lebensfroh: I am not asking what *eventually* happens, as a *result* of the event of the cell dying. I mean the event itself. What is it *precisely,* that has happened at that moment?

Todtkopf: Obviously, there was some divergence from normal functioning, and the cell did not recover.

Lebensfroh: Why didn't it recover? As the Russian biologist Gurwitsch and others showed, sometimes living cells can recover from the grossest sorts of disturbances. So, for example, Gurwitsch centrifuged fertilized egg cells until the visible structures in the cell had been destroyed, and yet the cells reorganized themselves and developed into adult organisms. What is it that occurs, at the moment when a living process, which was viable before, loses that capability?

Todtkopf: Actually, I must admit I don't know. Maybe there is no simple general answer. Of course there are millions of papers about aging of tissue and various damage mechanisms which can lead to the death of cells. But actually, I don't recall anyone having posed exactly the question you are asking, in such a straightforward way.

Lebensfroh: Isn't that a bit strange? After all, you were just claiming the molecular biologists had uncovered the molecular basis for the main processes which occur in living organisms. But as for such a central issue in biology, as I now have raised, you haven't even begun to address it. Doesn't that suggest some problem with your thinking?

Todtkopf: I see what you mean. But maybe the answer is very complicated.

Lebensfroh: If you had studied how Gauss determined the orbit of Ceres, you would at least know how the question would have to be approached experimentally. What is the characteristic of the orbit of a comet, for example, which is headed for a collision with the Sun? What is the *change* in orbital *characteristics,* between a "healthy" orbit and an orbit which might differ at first only imperceptibly from the healthy one, but lead inexorably to the destruction of the comet?

Todtkopf: How can you compare the processes of a living organism with the orbit of a comet? Another of your wild analogies.

Lebensfroh: I am not comparing the two as objects. I am talking about how we have to *think* about two problems that share a common, crucial methodological feature.

Todtkopf: Well, it doesn't help me to bring in the astronomical example. I saw that long article in *Fidelio*,[4] but I didn't work it through.

Lebensfroh: Why not?

Todtkopf: My friends all told me it is very difficult.

Lebensfroh: Why in the world, should it be regarded as an argument *against* doing something, to say it is difficult? If what Gauss accomplished were just trivial, so people could swallow it at one gulp, like a doggie biscuit, then it wouldn't be worth much, would it?

Todtkopf: I guess not.

Lebensfroh: And didn't Gauss himself work on this for months, and other scientists spend years and decades or even lifetimes struggling to work through a crucial paradox and make a fundamental discovery of principle, coming back to it again and again from different angles until they had succeeded, for the benefit of mankind, in mastering it? Didn't Beethoven oftentimes spend years developing a single composition?

Todtkopf: He did.

Lebensfroh: Then we should be happy when the essentials of a crucial discovery, and relevant materials, have been put together in such a way that we don't have to waste time on non-essentials, but can get to the real issues directly. Because, truly, we live in a world where there is no time to waste. So we should concentrate on the difficult things, and brush trivial things aside.

Todtkopf: I agree. But can you at least tell me what Gauss's work has to do with biology?

Lebensfroh: The oldest, classical problem in astronomy, is that when you observe the motion of the Sun or any planet in the sky, that motion actually results from many different motions, all acting during any arbitrarily small interval of the observed motion. So, the motion of Mars in the sky, for example, involves Mars' own orbital motion, the rotation of the Earth, the orbital motion of the Earth with respect to the Sun, the precession of the equinoxes, and even still other, more subtle and partly even not-yet-discovered cycles. The subtler point is, none of these motions is strictly independent from the other, but each one reacts to the existence of the others.

Todtkopf: Then, how is it possible to disentangle them?

Lebensfroh: There is no formal mathematical solution. But there does exist a method of *experimental measurement* based on so-called *analysis situs,* which Kepler applied in a masterful way to his founding of modern astronomy. The crucial point is, that the principles or "dimensionalities" of action we are looking for are axiomatically distinct, linearly incommensurable principles; each is characterized by a different characteristic curvature in the infinitesimally small. Their mutual action generates dense singularities. Second, the ensemble of such principles must be harmonically ordered according to a still higher principle.

Todtkopf: How do you know that?

Lebensfroh: That is Kepler's higher hypothesis, that our Universe is ordered in that sort of way. He demonstrated that the harmonic organization of motions of our solar system is uniquely coherent with that hypothesis, and in his snowflake paper he did the same thing for the microscopic domain, too—at least provisionally.

Todtkopf: I will have to believe you. But get to my question: what does this have to do with biology?

Lebensfroh: Very much, obviously. But in our discussion the particular issue keeps coming up, that the processes in living tissue are determined by more than one fundamental ordering principle. We have one set of principles—the one you associate with "ordinary physics and chemistry," and which you and your colleagues observe operating also within living organisms, at least to a very great extent. However, in living tissue another, higher set of principles—a higher geometry, in effect—is superimposed upon those "inorganic" principles. In fact, we can even say, that the higher principle *rules* the lower one, even though the effect of the higher geometry might only appear as a virtually infinitesimal displacement from the pathway, that the process would have followed, had only the lower, inorganic principles been active. Nevertheless, the overall cumulative effect of that "infinitesimal deviation," is enormous. This sort of situation is quite familiar from astronomy. There, the most powerful, "tectonic" forces are the ones connected with what appear at first as barely perceptible, infinitesimal deviations or anomalies within otherwise well-determined orbits.

Todtkopf: What you say seems strange to me. How can it be that a "strong" force appears as the most infinitesimal?

Lebensfroh: Here is another case, where a key point of method can hardly be communicated effectively, without

geometry. But this time maybe you will offer more patience than last time I tried.

Todtkopf: I am definitely in an excited state.

Lebensfroh: Good. Now take this piece of paper, and observe how I role it into a cylinder. No problem, eh?

Todtkopf: Very easy.

Lebensfroh: And now I roll it into a conical shape.

Todtkopf: Also no problem.

Lebensfroh: And many other shapes are possible, obviously. But what about giving the paper a spherical shape, or even part of a sphere. See, here I have a globe and I am trying to bend the paper onto its shape.

Todtkopf: I see, it doesn't work. You get creases all over and it still doesn't really fit.

Lebensfroh: And what would happen if I tried to make part of the surface of the globe into a flat surface?

Todtkopf: You would tear it, for sure, if it were made of some material like paper which doesn't stretch.

Lebensfroh: Is that problem a matter of how large the portions of surface I use?

Todtkopf: Evidently not.

Lebensfroh: So, then, the characteristic which causes these violent creases and tears—and I guess you will agree, these would be typical of "strong forces"—is manifested as a virtually *infinitesimal* difference at the level of a tiny section of the spherical surface vis-a-vis the flat surface. Of course, when I look at larger portions of the surfaces, the discrepancy in shape and characteristics becomes macroscopically evident.

Todtkopf: OK, I get it. So you want to say, for example, that we should think about the higher principle acting in living tissue as a kind of "curvature" imposed on an otherwise relatively "flat" geometry of non-living physio-chemical processes.

Lebensfroh: Wonderful!

Todtkopf: So that, if we just examine a small, isolated aspect of the living process, the effect of that curvature might appear virtually infinitesimal. But, if your approach is correct, somewhere in there we must find extremely intense forces of tearing or wrenching between the geometries. Because they are axiomatically incompatible. What form would those "creases and tears" take?

Lebensfroh: That question obviously takes us beyond mathematics, into the domain of experimental biophysics. This is exactly the area of Alexander Gurwitsch's fundamental work, which led him to the discovery of the so-called "mitogenetic radiation," or constant photon emission from living tissue. This radiation is so extremely weak, many orders of magnitude weaker than the metabolic energy of the tissue itself—so weak that most scientists today regard it as an irrelevant, mere curiosity devoid of biological or biochemical significance. This is because they don't understand the elementary point you just grasped. Alexander Gurwitsch and his followers developed an elaborate series of unique experiments based on the characteristics of this very weak radiation, and all directed at disentangling and measuring the higher principles of ordering of living processes.

Todtkopf: What did they discover?

Lebensfroh: Well, this was literally a life's work, and worth more than five minutes' discussion. But without my going into the experimental method, perhaps you might, in conclusion, like to hear how one of Gurwitsch's students summarized some of the main *conclusions* of that work. Actually, the conclusions are *questions:* they lead into an entirely new domain of biology, which has barely been explored up to this day. Here is the quote:

> The conclusion was that the harmonic movements observed in a normal cell are caused by a certain factor related to the cell as a whole and this factor is not destroyed or inactivated by the destruction of the visible intracellular structures or processes. Hence, *space-time connections between separate intracellular structures or processes are not caused by any properties of the structures themselves.* A further conclusion was, that together with stable structures in which the molecules are bound by means of various types of chemical bonds, there are *unstable* molecular constellations in which the molecules are not connected with each other by any of such bonds, but where their association is maintained by a continuous influx of energy. . . . Such labile, energy-dependent molecular constellations were designated by A.G. Gurwitsch as *'unbalanced molecular constellations'*. . . . However, the continuous influx of metabolic energy is a *necessary* condition, but *not the only one* for the existence of unbalanced molecular constellations. Their existence is elicited by a certain dynamic factor, whose action, although somehow connected to a continuous utilization of metabolic energy, is quite independent.

Todtkopf: What are those "unbalanced molecular constellations"? I don't know of such a thing in chemistry, even today.

Lebensfroh: Well first of all, you might have fun thinking about the last of Gurwitsch's conclusions, mentioned above, in relation to physical economy. What is involved by the impact of scientific and technological progress on the investment cycle (metabolism) of free energy and energy-of-the-system of an economy? As for Gurwitsch's "unbalanced molecular constellations," I think we illustrated that principle in our very conversation today.

Todtkopf: How so?

Lebensfroh: Well, obviously, the living process is a constant battle to keep those molecules from slipping back into their accustomed, banal, stupid, boring inorganic state. What must be supplied, to accomplish that, is not "energy" in the ordinary sense, but rather something akin to what Nicholas of Cusa did for me the other day, and what I have tried to do for you in these last two talks. Don't you think those great men are to be honored and emulated, who constantly raise people upward toward the passionate pursuit of truth. These are the real benefactors, fathers, and leaders of the human race!

Jonathan Tennenbaum heads the Fusion Energy Foundation in Europe.

For Further Reading

"How Gauss Determined the Orbit of Ceres," by Jonathan Tennenbaum and Bruce Director," in *Fidelio,* Summer 1998, published by the Schiller Institute, Inc., P.O. Box 20244, Washington, D.C. 20041.

BEYOND MOLECULAR BIOLOGY

The Biophoton Revolution

by Jonathan Tennenbaum

Over the last 20 years, blacked-out from the pages of standard textbooks, and only seldom represented in the leading professional journals, a new, revolutionary field of biological research has emerged: the investigation of the spontaneous photon radiation emitted from living cells, as a "window" onto the most fundamental life processes. At present, experimental investigations related to this "biophoton" emission are being carried out in about a dozen laboratories and institutes, including in Germany, Italy, Switzerland, the Netherlands, Poland, Russia, China, India, and Japan.

A number of these research groups have joined forces to create an International Institute of Biophysics (IIB), which is now coordinating much of the research in this area. Over the last several years, this author has had the privilege of participating in several of the yearly symposia of the IIB, held in Hombroich, Germany.

The fact, that practically all living processes are light emitters—albeit usually at an extremely low level—was first discovered by the great Russian biologist Alexander Gurwitsch in the 1920s. Gurwitsch demonstrated in 1923, that when two onion roots are situated in a common plane, in such a way that the growing tip (meristem) of the first root points toward a point *X* along the axis of the second root, at a distance of several millimeters, then the frequency of cell division (mitosis) was *increased* in the region of *X*, compared to the opposite side of the second root.

This "mitogenetic effect" (as Gurwitsch called it) was not affected when a transparent quartz window was placed between the two roots, but it disappeared when he replaced the quartz window by ordinary glass or opaque materials. By a variety of further experiments, Gurwitsch was able to establish that the *physical agent* of this stimulation of the rate of mitosis in the second root (the mitogenetic effect), was a very weak, ultraviolet light radiation emitted from the meristem of the first root. He called this "mitogenetic radiation."

Soon, Gurwitsch and his co-workers were able to demonstrate that countless other biological objects, including animal tissue, cultures of microorganisms, and even some biological materials such as blood, emit mitogenetic radiation. Gurwitsch found that specially prepared cultures of yeast cells, grown on agar blocks, made the most convenient and reliable detectors for the study of mitogenetic emission. Typically, the yeast culture blocks were divided into adjacent pairs; one side was briefly exposed to an experimental object as "source," while the other was optically shielded as a control. Subsequently, both cultures were incubated for a certain time; then the cells were fixed and the number of mitoses (seen as "buds" on the yeast cells) were counted under a microscope for the exposed culture and for the control.

The presence (and to a lesser extent, the strength) of the mitogenetic radiation revealed itself in a significantly positive difference in the exposed cells relative to the controls. Gurwitsch and his co-workers developed this technique to the point, that they could even obtain *spectra* of the mitogenetic radiation, by interpolating a diffraction apparatus between the source and detector.

A Science of Theoretical Biology

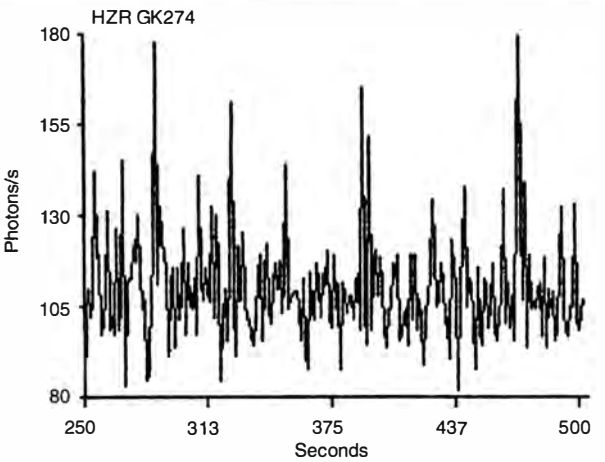
Fortunately, Gurwitsch was no mere experimenter, but one of the greatest *theoreticians* of biology in this century. In fact, it was his conception of the biological field, developed in connection with countless experimental studies of embryology, morphogenesis, and histology, which originally led him to *hypothesize* the existence of some sort of distant, radiative interaction between cells. The experimental demonstration of the mitogenetic effect by the famous "onion root" experiment—hailed at the time as one of the most important experimental discoveries of the century—by no means distracted Gurwitsch from his main goal, namely the creation of a comprehensive Science of Theoretical Biology.

In the subsequent period, Gurwitsch and his growing school of students and collaborators, transformed mitogenetic radiation into a powerful experimental technique for fundamental biological research. Mitogenetic radiation attracted worldwide scientific interest and became, in the course of the 1930s, one of the main areas of biological research in the Soviet Union. An enormous number of interesting and important results were published in nearly every major domain of biology, including also neurophysiology and cancer research.

Unfortunately, for reasons I indicate elsewhere (see box, p. 30), Gurwitsch's work on mitogenetic radiation came under heavy attack in the 1930s—not accidentally at the same time as funds began to be poured into molecular genetics and molecular biology, which were built up to take the dominant position in biological research in the postwar period. After World War II, the whole subject of mitogenetic radiation nearly disappeared from view, at least in the West; while in the Soviet Union, a few groups—centered on students of Gurwitsch—continued active experimental work in the directions he had initiated.

The main attack on Gurwitsch consisted in the claim, that all the thousands of experiments by Gurwitsch's and other groups (including in France and Germany), demonstrating the mitogenetic effect, were "wrong," and that Gurwitsch's mitogenetic radiation simply "does not exist." To bolster this assertion—hardly credible to anyone familiar with the quality of the scientists involved, and their painstaking methods of work—it was pointed out, that Gurwitsch's experiments were exclusively based on the use of *biological objects as detectors;* whereas attempts to detect the radiation by technical means (photodetectors) had failed or yielded ambiguous results. The argument was also raised, that a light radiation, so weak that it could not be detected by technical devices—not to speak of by the human eye itself—could hardly be expected to have any noticeable effect on biological objects.

In fact, as we know today, the spontaneous photon radiation of living organisms is indeed too weak—given the problems of sensitivity and background noise—to have been reliably measured by the kinds of photodetector apparatus that were available in the 1930s and 1940s. In 1954, however, a group of Italian astronomers who had been working on the development of supersensitive light detectors, discovered that sprouts of wheat, corn, beans, and other plants constantly radiate light at an intensity of the order of 10 to 100 photons per second per square centimeter of living tissue. These results were first looked on as a curiosity in the West, but they gave a considerable boost to the work of Gurwitsch's followers in the Soviet Union.



LOW LEVEL LUMINESCENCE OF CUCUMBER SEEDLINGS

Photons per second observed between 250 and 500 seconds in the course of time. The dark-count rate is of the order of 10 photons. The figure is from Fritz Popp's experimentation, as he reported in "Principles of Quantum Biology As Demonstrated by Ultraweak Photon Emission from Living Cells," International Journal of Fusion Energy, *Vol. 3, No. 4, Oct. 1985.*

Fritz Popp's Experiments

In 1973, some of the newer Soviet results caught the attention of the German biophysicist Fritz Popp and his collaborators. At that time, Popp was working in cancer research; he and a group of graduate students were trying to find an explanation for the extremely powerful carcinogenic action of the substance 3,4-benzpyrine, compared to the very similar, but essentially harmless 1,2-benzpyrine. Popp's hypothesis was, that the anomalously strong carcinogenic action of the former molecule was somehow related to a known, peculiar feature of its absorption and emission spectra in the ultraviolet range. The idea, that the carcinogenic action of 3,4-benzpyrine might be caused *directly* by its *optical* characteristics—and not necessarily mediated through its chemical reactivities—went directly against the prevailing, molecular-biological mindset of most cancer researchers.

But to put the matter rather simplistically: How could the posited *optical* action be accounted for, unless there were a source of light in the cell? And unless very small photon "signals" could trigger gross changes in the behavior of cells? The Soviet work on "ultraweak" photon radiation of cells seemed to provide the missing link.

In order to learn more about this photon radiation, Popp and co-workers developed and perfected over many years, a photo multiplier-based experimental apparatus with a high sensitivity and high signal/noise ratio, specially suited to the measurement of "ultraweak" photon emission of biological objects. With the help of this greatly improved "biophoton" detector, Popp and his collaborators have been able to discover a number of remarkable and highly *anomalous* characteristics of the biophoton radiation. Indeed, taken together, the results of Popp and his growing circle of international collaborators, demonstrate the existence of principles of organization of living processes, which are entirely incompatible with the basic assumptions of molecular biology.

Biophoton Radiation in Brief

We cannot go into the matter in depth here, but the following brief summary should give the thoughtful reader a sense of the fundamental importance and anomalous character of biophoton radiation. This should wet the reader's appetite for more in-depth discussions of these matters in coming issues of *21st Century*.

(1) It is well established that spontaneous, ultraweak photon emission is a ubiquitous phenomenon throughout nature. This ultraweak emission is completely different in nature from the familiar, much more specialized phenomenon of "bioluminescence," typified by fireflies for example, and whose intensity is many orders of magnitude larger. The intensity of ultraweak emission differs very greatly between cell types—undisturbed animal cells having generally the lowest rate of emission—but also varies greatly from moment to moment for any given culture or organism studied. The emission often contains "trains" of very short (sub-millisecond) "photon bursts" with a tendency toward recurrence, but with constantly shifting periodicities.

(2) Judging from experiments with interference-filters, the typical wavelength spectrum is spread over a broad band, from the near-infrared into the ultraviolet; the intensity distribution varies with time and the biological object studied. Bursts in the ultraviolet range tend to be found in tissue or cultures undergoing rapid cell divisions, in agreement with Gurwitsch. However, the exact relationship between Gurwitsch's mitogenetic radiation and the general phenomenon of ultraweak photon emission, as detected with the apparatus of Popp, has not been clarified.

(3) The intensity of biophoton emission is extremely sensitive to virtually any disturbance or other change in the biological system. For example, the introduction of toxic substances in extremely small concentrations—concentrations lower than those required to cause noticeable effects on metabolism or morphology—are typically followed by a sharp burst of biophoton emission.

(4) In spite of the obviously intimate relationship between biophoton emission and the biological state of a given object, it has proven impossible to discover any strict, mechanical correlation between variations in photon intensity, on the one hand, and any *specific* known set or type of biomolecular events on the other.

(5) On the contrary, the evidence of many biophoton experiments points to the existence and involvement of a *correlation among a large "continuum" of events* occurring virtually simultaneously, not only within a given cell, but between large numbers of cells in a tissue or population of microorganisms—events which could not *possibly* be correlated, within the extremely short times involved, by "chemical messengers" or similar mechanisms of molecular biology.

(6) One of the clearest demonstrations of the above-mentioned fact is the dramatic change in the photon emission behavior of two biological objects, when they are placed into optical communication with each other.

For example, in experiments conducted by Popp and others at the IIB laboratory in Hombroich, Germany, two cuvettes containing *Gonyaulax polyedra* were mounted in adjacent dark chambers and the real-time spontaneous photon emission of each was measured by a separate photo multiplier detector, the axes of the two detectors being parallel. When a shutter was opened, allowing the two cuvettes to "see each other" along an axis perpendicular to the axes of the photomultipliers, then the emission of both cultures changed markedly: The emissions became closely correlated, with a strong tendency toward simultaneous, short bursts, as well as a general increase in emission activity.

(7) Another, somewhat different demonstration of the same principle is provided by studies of the strongly nonlinear character of the biophoton emission of suspension cultures of cells or microscopic animals as a function of their *density*.

In the case of suspensions of *Daphnia magna* at the same development stage, for example, the curve of the average total photon intensity as a function of the number of organisms in a fixed-volume cuvette, displays a succession of several maxima and minima, which is hardly understandable if we assume a simple additivity of the emission from the individual organisms, together with the effects of absorption and opacity as the density changes. Close study rules out the possibility of chemical communication or "collision" models as an explanation of this phenomenon, and strongly points to a biologically significant resonance-interference effect: The total intensity has a pronounced *minimum* at a density corresponding to the "natural" distance between adjacent animals when populations of them are living in natural conditions, but has pronounced *maxima* in the regions where the density is 50 percent and 150 percent of the "natural" density.

(8) Although much more extensive studies need to be done, it has been found that the cells of at least some cancer types (for example, hepatocytes vs. HTC cells) distinguish themselves relative to the corresponding healthy cell types by a striking difference in the curve of emission as a function of cell density—the former showing monotonically *increasing* emission with density, and the latter displaying a nonlinear density dependency with decrease toward a minimum.

This is interpreted, roughly, to indicate that the processes in the population of cancer cells are no longer correlated in the strongly harmonic, coherent manner characteristic of healthy tissue.

(9) Finally, the photon emission from a given living system (organism or culture) displays characteristics of optical coherence, particular *temporal* coherence, indicating that the sources of emission—to the extent they can be localized within the system at all—are not independent, but are strongly correlated with each other in the manner suggested by the image of a *multimode, multifrequency* laser.

One indirect indication of this, according to the theoretical analysis by Fritz Popp (which cannot be dealt with here) is the shape of the *decay curve* of light re-emission by biological objects following their exposure to intense light. Living systems display a characteristic, *hyperbolic* decay-curve, while nonliving materials (except some with highly ordered internal structure, such as some crystals) typically re-emit in an *exponential* decay curve. In particular, after a more rapid initial decay, the living material then has a much slower re-emission. It appears to be a ubiquitous characteristic of living matter, to maintain an elevated energy state for as long as possible after the initial light exposure.

'Photon Sucking'

(10) Many experiments point to a further anomaly which Popp and his colleagues refer to as "photon sucking"! Under certain circumstances, living organisms, placed in the vicinity of a medium of excited atoms or molecules, appear to actively *suppress* light emission by those molecules. How? By the living process *integrating* the excited states of the neighboring molecules into its own, coherent electromagnetic field.

Popp likens the result to the so-called destructive interference of waves; in this case, those phase relationships are "trapped" or "cancelled out," that would otherwise lead to emission of photons from the molecules.

The demonstration of "photon sucking" is a wonderful thing, not least of all because it defies any interpretation in terms of Newtonian, "ballistic" conceptions of light emission, which are typically carried over into the image of a photon as a kind of bullet shot out from the emitting atom or molecule. In this case, time seems to be reversed, and with it the "target" which controls the path of the bullet!

This brief introduction has focussed mainly on the experimental results per se. I have left it to Drs. Lebensfroh and Todtkopf, in the preceding article, to discuss the really interesting part—the choice of *crucial hypothesis*.

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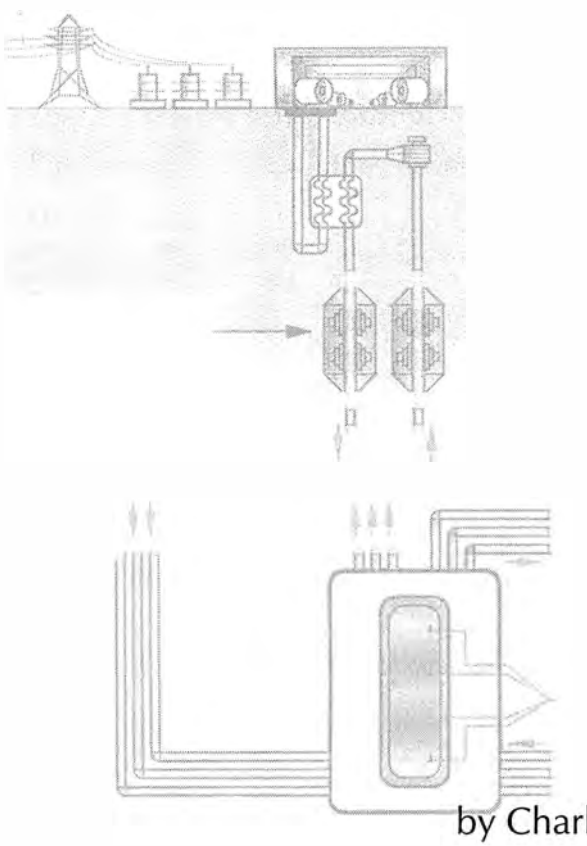


THE BURN-WAVE FISSION REACTOR

H-Bomb Science to Power the World

by Charles B. Stevens

From the world's pioneers in nuclear explosive devices comes a revolutionary new design for safe, foolproof fission reactors to power human civilization for the next century.

The world is currently living in a "dark age," with a huge and growing deficit of electric energy generation. Bringing the world's population up to the standards of living now enjoyed by the industrial nations, will require the construction of 10,000 electric power plants in the first decade of the 21st century, each of which generates a gigawatt (1 billion watts) of electric power.

Scientists at Lawrence Livermore National Laboratory in California have developed a new design for a safe, fully automated, underground nuclear fission reactor that could help meet this requirement. The reactor is based on a new concept of a *fission burn-wave,* derived from the study of nuclear bombs, which utilizes nuclear fuel 30 times more efficiently than current fission reactor designs. The reactor core is a relatively small cylinder, about 3 meters in diameter and 10 meters long, weighing about 100 tons, which means it can be mass-produced at one location, and readily transported.

The reactor design was developed by a team of leading nuclear scientists, working under the direction of the legendary Dr. Edward Teller: Drs. John Nuckolls, Lowell Wood, Muriel Ishikawa, and Roderick Hyde. The reactor concept was initially presented in a technical paper given at a June 1996 international conference on Emerging Nuclear Energy Systems, held in Russia: "Completely Automated Nuclear Reactors for Long-Term Operation II: Toward a Conceptual-Level Point Design of a High-Temperature Gas-Cooled Central Power Station System."

The burn-wave reactor is fully automated and is designed to operate without refueling for its full 30-year lifetime. The output of the reactor is high-temperature, high-pressure helium gas, heated to a temperature of 1,200 kelvin. The thermal output would be on the order of 2 gigawatts of heat. Existing combined-cycle turbines, based on aero-derivative systems already in use with electric plants powered with natural gas, could transform this output at 60 percent efficiencies, and thus produce more than 1 gigawatt of electricity. Alternatively, the output of the reactor could be utilized as high-quality thermal industrial process heat.

The design of the heat extraction system of the reactor is self-regulating, so that the reactor shuts down if the temperature of the helium rises above a certain level. And the reactor would be buried at a depth of more than 100 meters underground, surrounded by hot, dry sand, in order to further guarantee its safety and security.

The burn-wave reactor has a cylindrical core, with a small nuclear ignitor region and a much larger nuclear burn-wave-propagating region. The larger burn-wave zone contains either thorium or depleted uranium fuel. This burn-wave zone utilizes the principle of fission fast-breeding to reproduce the initial nuclear fission fuel present in the small nuclear ignitor zone.

A key aspect of this new design is that it is fully automated, by using redundant thermostating modules. Each module, composed of bulbs of the light element lithium-6, strongly absorbs neutrons when the core reaches a certain temperature limit set by the design. The thermostating modules are injected in any region of the reactor to absorb neutrons and thus immediately slow down the fission chain reaction. If enough lithium-6 bulbs are injected, the fission chain reaction will be completely suppressed. Conversely, if the temperature of the reactor falls below a certain limit, the lithium-6 bulbs are extracted, and the chain reaction starts up again. In this way, the chain reaction becomes self-regulating; it proceeds only when heat is being extracted from the core, and full thermal homeostasis is automatically maintained.

Intervention by human operators is required only at the startup of the reactor, and at its shutdown. At the shutdown point, the reactor's reactivity is irreversibly quenched by the injection of neutron-absorbing materials.

The heat from the reactor core is removed by a primary extraction system using helium gas. A secondary system, also using helium gas, carries the heat out of the reactor for either direct industrial processing, or for use in powering electric generators.

What's Different?

The burn-wave concept is the result of more than five decades of military research in the design of nuclear explosive devices. What makes this new reactor so small and efficient, is that it does not use the traditional static critical mass to sustain the nuclear fission chain reaction. In conventional fission reactors, a sufficient mass of enriched uranium metal is brought together such that neutrons produced by one fission reaction will be able to initiate other fission reactions before escaping the entire assembly. The conventional nuclear reactor runs for a period of time, usually a couple of years, until a certain proportion of the uranium-235 has undergone nuclear fission. At this point, the fuel elements are "spent" and must be replaced—that is, the reactor must be refuelled.

In conventional breeder reactors, the escaping neutrons are used to breed more nuclear fuel in "blankets" surrounding the reactor assembly. However, before that newly generated fuel can be used in power plants, it must first be extracted from the blanket material by fuel-reprocessing.

In contrast, in the new burn-wave reactor, a small, ignitor assembly of 20-percent-enriched uranium is placed within the center of a cylinder of 75 to 100 tons of thorium. When this assembly is ignited and allowed to go critical, it generates a fission burn-wave that proceeds in two directions, toward both ends of the cylinder. Fast neutrons (those with high velocity and high energy) from this critical ignitor region breed new fissile fuel in the thorium that is adjacent to the ignitor region. This produces a new ignitor region, so that, as the first ignitor region burns up, a new ignitor region is generated directly in front of it—a self-sustaining fission "burn-wave."

In this way, the burn-wave reactor is able to produce the same energy output as a conventional nuclear reactor, while utilizing only 100 tons of nuclear fuel. In comparison, a conventional light water reactor requires between 3,000 and 4,500 tons of fuel. The burn-wave also achieves a more complete burn-up of the fission fuel—more than 50 percent.

Figure 1
REACTOR CONFIGURATION AND UNIQUE SAFETY FEATURES

The burn-wave reactor provides high-temperature heat that can be used to generate electricity. In order to maximize both the safety and the economic return of this reactor, it must operate safely and reliably without maintenance or repairs, at high temperature for many years.

The reactor generates huge amounts of thermal energy, which must be continually removed in the form of approximately 2 GW of thermal power, which is used to generate electricity. The reactor is designed with two sets of coolant loops: a large primary set for use during normal operations, and a smaller secondary loop-set for removal of afterheat during any potential loss-of-coolant accident and for multi-century intervals after the reactor is shut down.

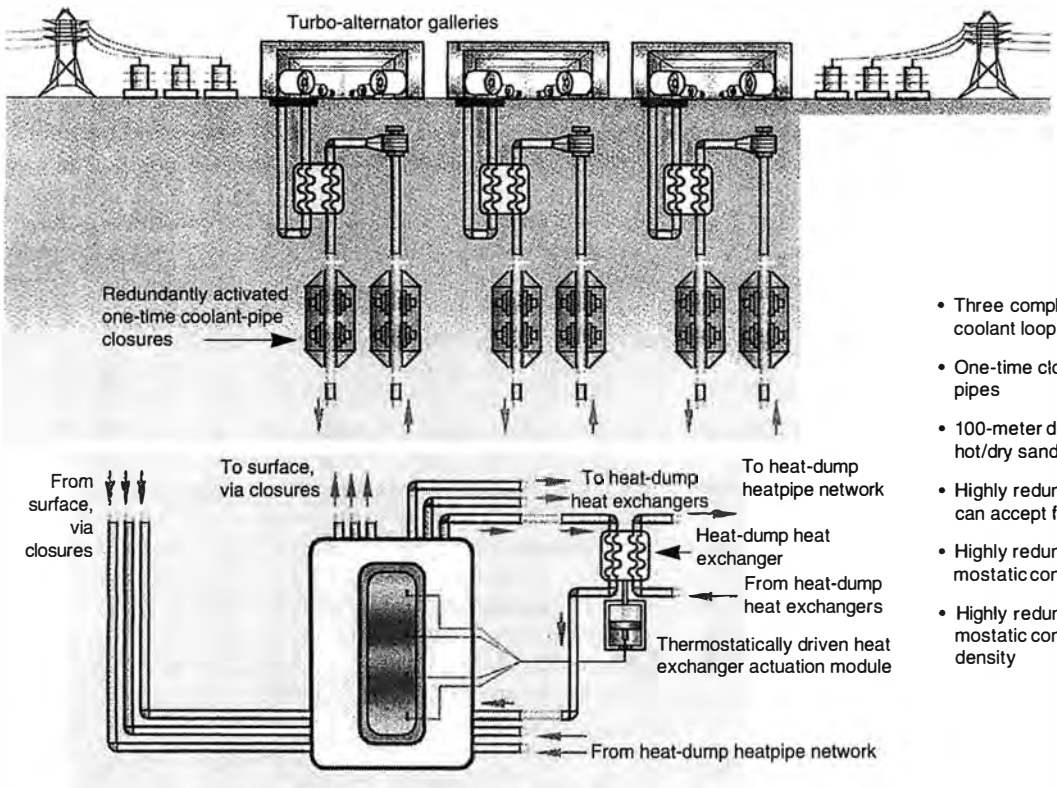
There are six novel features in this new type of reactor, which are intended, the designers say, "to make obvious to any reasonable person its great safety as a large-scale source of high-grade heat."

- Three completely independent, physically separated, coolant-loops, each of which can operate when the reactor is at full power, are the first line of defense against all types of "standard" loss-of-coolant accidents.
- The coolant-loops have one-time-operation, automatically-started coolant-pipe closures, which back up automatically started conventional mechanical valves. This assures that fission products carried by coolant gases can never reach the surface—or the biosphere—in significant quantities.
- The reactor is located more than 100 meters underground, providing a great amount of mass and distance between the biosphere and the radioactive reactor core. This allows several independent and highly effective safety measures, both active and passive, to be taken, in the event of an accident. It also completely precludes the possibility of covert diversion of reactor products for military purposes.
- The heat-dump for the reactor (loosely packed sand that sits on top of it) acts automatically, without human ac-

The Reference Design

In the basic, or reference design of the burn-wave reactor, the entire core is is embedded in a neutron reflector and a radiation shield. A multiplicity of thermostating modules (Figure 2) is used to maintain a uniform temperature throughout the core. The thermostating modules make use of simple automatic controls which release isotopically enriched lithium when the local material temperature rises above a temperature of 1,200 kelvin. Because lithium-6 is a great absorber of fast neutrons, this lowers the local neutron flux, which, in turn, reduces the nuclear power production in that region.

The heat from the reactor core is removed by a primary extraction system using helium gas. This system is triply redundant. In others words, there are three separate helium circula-



- Three completely independent coolant loops, each full power-rated
- One-time closures of coolant gas pipes
- 100-meter diameter bubble of hot/dry sand
- Highly redundant heat-dump that can accept full-power afterheat
- Highly redundant, distributed thermostatic control of core temperature
- Highly redundant, distributed thermostatic control of core fuel power density

Source: Lawrence Livermore National Laboratory

tion, to absorb all the afterheat of the reactor's core, effectively forever, no matter what the circumstances of the reactor are. In fact, the heat dump is designed to prevent human intervention in its operation.

• The highly redundant thermostatic control of the reactor core's temperature is the second, entirely independent line-of-defense against all types of loss-of-coolant accidents. It connects the core's fuel-charge—automatically and swiftly, with triple redundancy—to the heat dump.

• The highly redundant and automatic thermostatic control of the core fuel-charge's temperature permits completely automatic operation of the reactor over its full range of thermal power demand, from 0 to 100 percent, from the moment of initial reactor start-up through the final shutdown. This eliminates all possible types of human operator error.

tion systems, each of which is capable of transporting out *all* of the heat generated by the reactor. A secondary system, also using helium gas, carries heat out of the reactor for either direct industrial processing, or for use in powering electric generators.

There is also another independent, triply redundant energy-dumping system, which is included in the design in order to passively transport afterheat out of the core in the event of a loss-of-coolant accident, or at the end of the reactor's operational life.

The reactor is designed for a 30-year lifetime of full operation, at which point the reactor's initial fuel loading of thorium or depleted uranium will have been burned up. The reactor will then be permanently shut down by the addition of a neutron absorber to the core. The core's spent fuel will simply undergo beta-decay in the reactor. The reactor is surrounded by design by hot, dry sand—the engineered heat-dump—which provides long-term protection against any environmental conditions that might lead to the release of residual radioactivity into the biosphere.

Why Fast Neutrons?

Thorium-fueled reactors are probably best for mass production, because thorium is both inexpensive and widely available throughout the world in high-grade ore deposits. The reactor is a breeder, in order to most efficiently use nuclear fuels, and to minimize the amount of isotope enrichment required to fuel these power plants. A fast breeder mode is required, because the slow (or thermal) neutrons utilized in conventional fission reactors are quickly absorbed by the reaction products of nuclear fission. Therefore, in order to operate and breed, the burn-wave reactor uses a fast-breeding mode in which the neutrons have high energies and do not suffer from such high rates of absorption by the fission products.

In this way, the burn-wave reactor achieves an operational life of 30 years without requiring any refueling. Thus, there is no need for human operators to intervene with the reactor core. This also inherently prevents the diversion of fissile materials to military purposes.

Neutrons that are generated during fission of the nucleus have energies of about 1 million electron volts—which roughly corresponds to a temperature of 10 billion kelvin. The burn-wave reactor is designed to keep these neutrons at about 10 percent of this energy level or, in other words, at about 100,000 electron volts. These are fast neutrons.

There are numerous advantages to having the reactor operate with fast neutrons:

- The cross sections (rates) for fissile fuel breeding are much higher.
- Higher cross sections also lead to a higher fuel burn-up.
- Materials that absorb fewer fast neutrons (than slow neutrons), such as niobium and tantalum, can be used for the core, which will enable the reactor to operate more efficiently over it's 30-year lifetime.
- The rate of neutron production per fissile reaction is much greater for fast neutrons than for thermal ones. This is notably the case for uranium-233, which is the primary fissile fuel powering the burn-wave reactor. When thorium-232 absorbs a neutron, uranium-233 will result. This is the primary fissile fuel bred in the reactor core, and it also powers the core during most of its lifetime in a thorium reactor design.
- Fast neutrons also generate some fission of thorium-232 or uranium-238. Although small compared to the rates of fission of the fissile fuels (uranium-233, uranium-235, and plutonium-239), the overall amount generated throughout the 30-year lifetime of the reactor is not negligible.

The Core

To generate 1 gigawatt of electricity over 30 years, the core of the burn-wave reactor must be in the shape of a right-circular cylinder approximately 3 meters in diameter and 10 meters in length. Alternatively, if a reactor with a 100-year lifetime is desired, the reactor could simply be made 33 meters long, or a reactor with a 10-year lifetime, would be 3.3 meters long while maintaining the same diameter of 3 meters in both cases.

A small nuclear ignition region is placed at the center of the core cylinder containing enriched uranium-235. This ignitor is embedded in a much larger breeding section containing either thorium-232 or uranium-238. This breeder section will also burn after fissile fuel has been generated in it.

The process occurs in the following manner. The initial ignitor zone reproduces itself in two directions—moving toward opposite ends of the cylinder. But, during operation only about 1 percent of the total core will consist of fissile fuel. This is comparable to the ratio that exists in natural uranium deposits. Given the feasibility of a high fuel burn-up—greater than 50 percent—the total fuel requirement for a 30-year reactor lifetime is about 100 tons. As noted above, this is much less fuel than the 3,000 to 4,500 tons of natural uranium required for fueling a 1-gigawatt electric conventional light water reactor during the three decades of its operational life.

The core is cooled with helium. This permits operation at much higher temperatures than conventional reactor systems that are water cooled. It also avoids the hazards arising from the reactions of water with high-temperature materials. In addition, using helium as a coolant makes the core's neutronic reactivity independent of the coolant, and therefore independent of any unfavorable results that might arise from the loss of any coolant.

The reactor core materials consist of niobium, tantalum, tungsten, and rhenium. These are widely available and also superior materials because of their long-term, high-temperature mechanical and chemical properties, which can be maintained to an adequate extent under the reactor's large neutron flows.

Starting the Burn-wave

The ignitor module is started up by the removal of material which absorbs neutrons. This one-time removal of the neutron "poison" causes the centrally located ignitor to go critical. Nuclear fission begins in the ignitor and concurrently, high-gain breeding begins in the the regions adjacent to the ignitor. This launches a nuclear deflagration wave—that is, a burn-wave—into these adjacent regions of unenriched fuel.

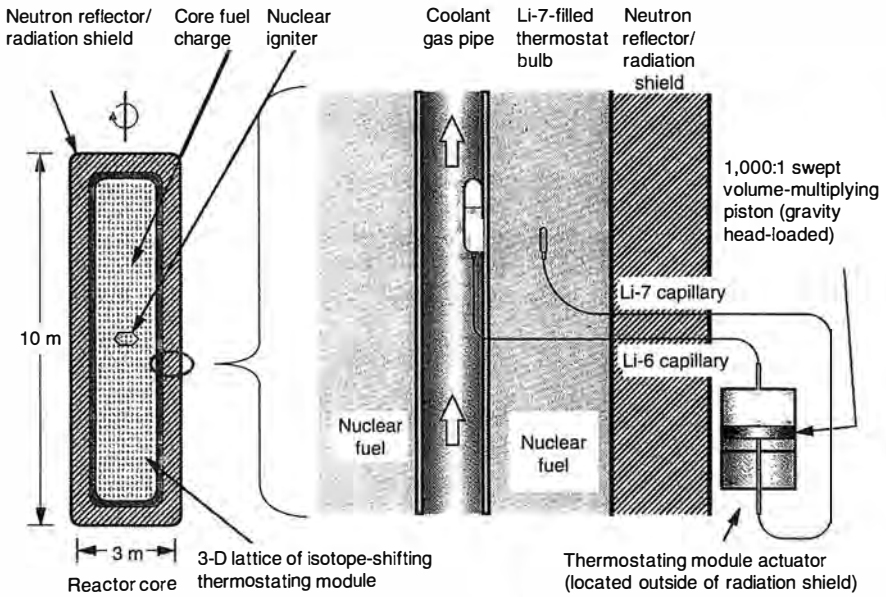
At first, the burn-wave moves out spherically until it reaches the outer edge of the core cylinder. It then becomes two oppositely directed burn-waves, moving down the axis of the cylinder toward both ends. The slow speed at which each of these burn-waves moves is determined by the rate at which heat is removed from the reactor core. At its fastest pace, the power is sufficient to supply 2 gigawatts of heat. (In the case of a thorium reactor, this fastest rate of propagation is bounded by the beta-decay of protactinium-233, which is relatively slow and is the rate-determining step for breeding of uranium-233 from thorium-232.)

The fully automatic regulation of nuclear power generation in the core is performed by uniformly distributed, functionally redundant thermostating modules. These act to intensely absorb the local neutron flux when the local material temperature exceeds the maximum temperature value of the reactor design. Therefore, this action quenches the local nuclear power production and assures thermal homeostasis of every portion of the reactor core. This homeostasis is sustained, despite the wide range of coolant flow, temperature, fuel composition, and neutron flux.

Each thermostating module acts by reversibly inserting neutron-absorbing liquid lithium-6 into small compartments located in the coolant-flow from a source outside the neutron reflector. This occurs under the drive action of a thermostating bulb filled with neutron-indifferent liquid lithium-7, which is emplaced in adjacent, substantially hotter nuclear fuel. A three-dimensional lattice of such thermostating modules, each independent of all the others, serves to regulate temperatures everywhere, at all times (Figure 2).

When heat extraction from the core is reduced, or even brought to zero, the reactivity of the neutrons is reduced, and even driven to zero. This results in the stalling of the burn-wave. If the heat extraction is increased, the core material cools, and the neutron-absorbing lithium-6 is removed from the core by the action of the thermostat system. This leads to a rise in neutronic reactivity to slightly positive levels, and the two burn-waves restart their motion toward the ends of the cylinder.

Figure 2
THERMOSTATING MODULE



Source: Lawrence Livermore National Laboratory

The fuel power density in the reactor core is continuously regulated by the collective action of a distributed set of independently acting thermostating modules, which provides a large negative temperature coefficient of reactivity just above the design-temperature of the core. These operate over very large variations in neutron flux, significant variations in neutron spectrum, large changes in fuel composition and order-of-magnitude changes in power demand on the reactor.

The modules are located throughout the core's fuel-charge in a three-dimensional lattice. Each module consists of a pair of metallic compartments, each one of which is fed by a capillary tube. The small thermostat-bulb compartment located in the fuel always contains Li-7, whose neutron absorption cross-section is essentially zero for the neutron energies expected. The relatively large module, located in a cooler location on the wall of a coolant tube, may contain variable amounts of Li-6, which has a comparatively large neutron absorption cross-section.

As the fuel temperature rises, the thermostat-bulb-contained Li-7 expands, expelling a small fraction of it. The modest volume of high-pressure Li-7 drives a piston, which pushes a larger volume (by 3 orders of magnitude) of Li-6 through a core-threading capillary tube into an intra-core compartment adjacent to but cooler than the thermostat-bulb which is driving the flow. There the Li-6 acts to depress the local neutron flux, thereby reducing the local fuel power density. When the local fuel temperature drops, Li-6 returns to the cylinder-and-piston assembly under action of a gravitational pressure-head, thereby returning the Li-7 to the thermostat-bulb whose now-lower thermo-mechanical pressure permits it to be received.

This arrangement provides the desired high-gain negative feedback of local-temperature-above-the-set-point on the local nuclear power density. Similar thermostating modules thermally connect the three passively convected helium-gas coolant loops to the heatpipe network of the engineered heat-dump when the multiply-sensed core temperature rises above the design set-point.

Behind each of the burn-waves, two regions of moderately enriched fissile material are generated. These two increasing masses of fissile fuel continue to burn, until fission product accumulation and burn-up of the fissile fuel finally makes the neutronic reactivity in this region negative. A burn-up of 50 percent is achieved in this manner. Figure 3 shows the typical conditions surrounding these burn-waves.

Pressurized helium gas at 1,200 kelvin removes heat from the core. A two-dimensional hexagonal lattice of pipes allows the helium to circulate axially throughout the core. Reactor fuel is placed between the helium flow pipes, and heat is transferred to the helium pipes through thermal conduction. In this manner, the helium is heated. A three-fold redundancy is built into the coolant loops, which, under normal circumstances, are powered by pumps located at the surface. The array of coolant pipes, which is the primary in-core structure, are made with a tantalum alloy which has the required long-term, high temperature creep resistance.

The entire reactor core is placed within a containment vessel. Because this vessel is outside the hot, neutron-rich core, it can be made with conventional steel alloys.

Six-level Safety Redundancy

The three-fold redundant system of primary coolant loops greatly reduces the possibility of a loss-of-coolant accident. Each of these three systems is fully capable of removing all of the reactor core's heat.

A second, totally independent cooling system has been added to the above. This is a passive system which surrounds the reactor. Given the failure of the three normal heat coolant loops, this system would convey heat. This engineered heat-dump surrounding the reactor is also triply redundant. It is designed to remove the afterheat when the reactor is shut down. However, in the case of an accident, this system is sufficient for removal of the reactor core heat via passive convection.

Coolant pipe closures act to robustly seal off the reactor from the biosphere, either in the case of an accident, or at

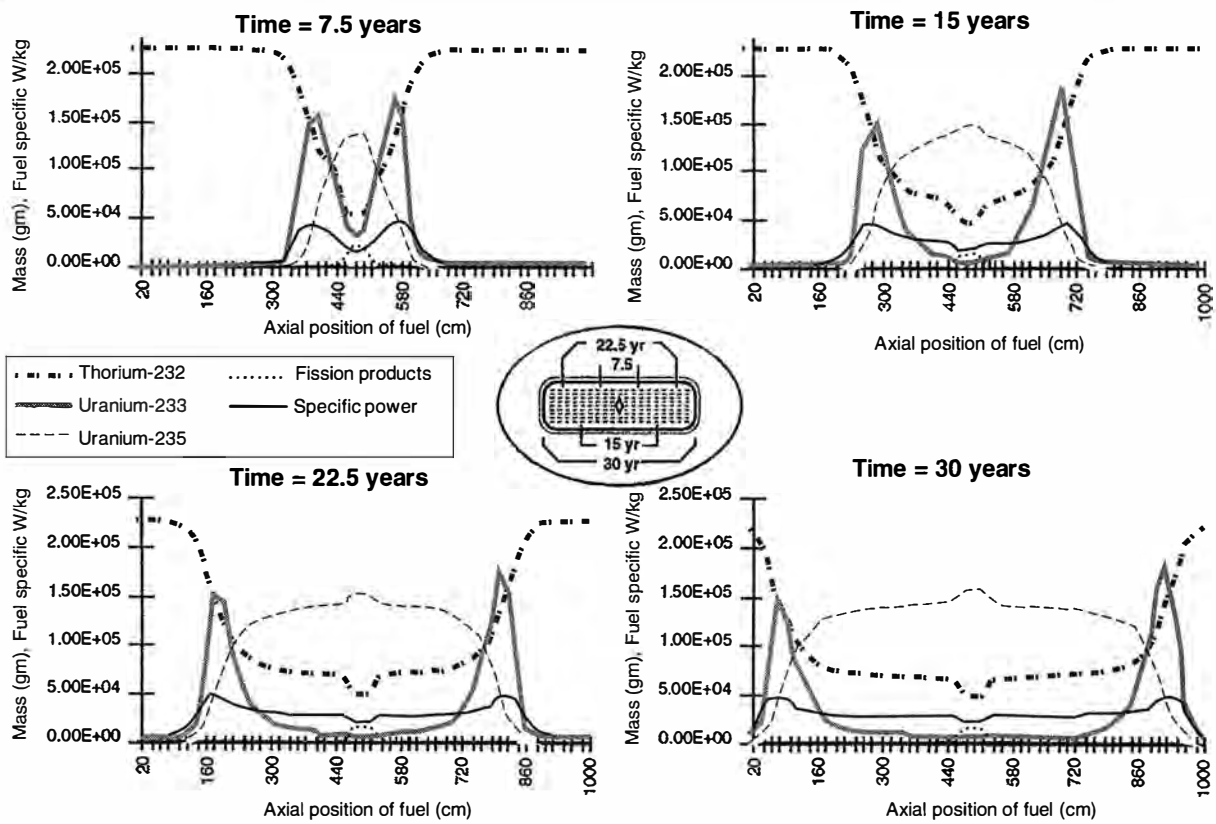


Figure 3
BURNWAVE DEVELOPMENT OVER TIME

Shown are some of the salient features of the fuel-charge of the core of the proposed reactor, at four times during its operational life, after nuclear ignition and with a continuous demand for the full approximately 2 GWt of power. The mass (in grams) of various isotopic components and fuel specific power (in W/kg) are on the x axis, and the fuel charge's axial position along its 10-meter-length is the y axis. The inset (center) shows the positions of the leading edge of the nuclear deflagration wave. E on the vertical scale stands for exponential.

Note that the neutron flux from the most intensely burning region behind the wave-front necessarily breeds a fissile-rich region at the front's leading-edge, thereby advancing the wave. After the wave's front has swept over a given mass of fuel, the fissile atom concentration continues to rise for as long as radiative capture of neutrons on available fertile nuclei is considerably more likely than on fission product nuclei, while ongoing fission generates an ever-greater mass of fission products. Nuclear power-production density necessarily peaks in this region of the fuel-charge, at any given moment.

Finally, well behind the wave's advancing front, the concentration ratio of fission product nuclei (whose mass averages half that of a fissile nucleus) to fissile ones climbs to a value comparable to the ratio of the fission to the fission product radiative capture cross-sections, the local neutronic reactivity goes negative, and both burning and breeding effectively cease—as is clear from comparing the various snapshots with each other, far behind the wave-front.

shutdown. These pipe closures will automatically close in the event of an accident in which a large amount of fission products is released into the helium gas stream.

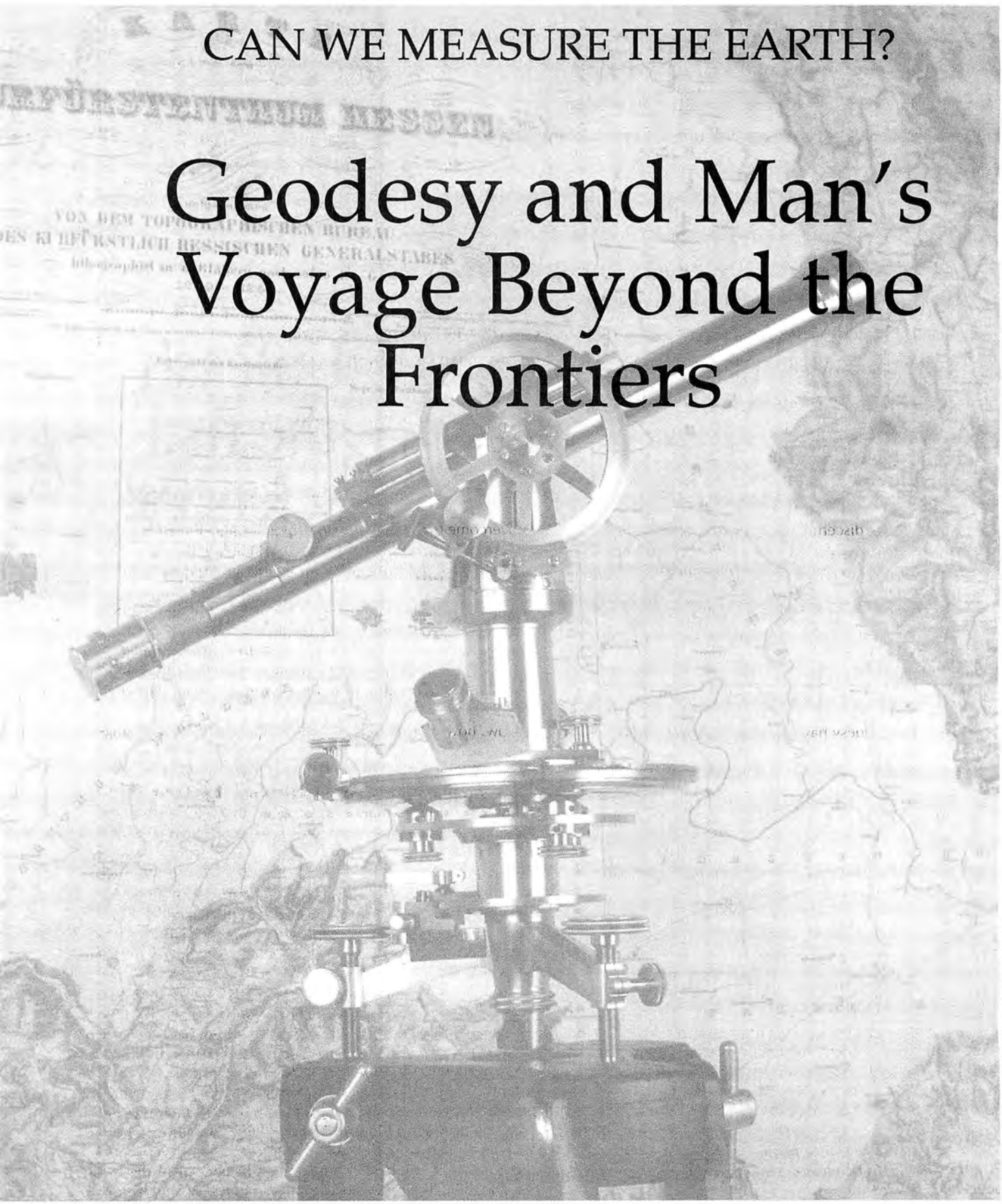
This revolutionary new design of a fission power plant is capable, with the current stock of uranium and thorium ores, of providing the whole world with electrical power and heat energy at levels per capita equalling those of the United States—and doing this for more than a century. It is also the case that no significant amount of "enriched" nuclear fuel (such as is needed for bomb-making) is required in this reactor design. Furthermore, the reactor is completely automated and self-regulating, and requires no maintenance over its 30-year operational lifetime. The small size and relatively low weight of the reactor means that it can be mass-produced on an industrial assembly line, and then readily transported to virtually any location.

As the designers of the reactor note in their technical paper, an "entirely fresh look at nuclear-energized large-scale power generation is called for, particularly in the light of rapidly increasing demand for electricity in the capital-poor Third World. . . ." They have designed a reactor to meet that challenge.

Charles B. Stevens is an associate editor of 21st Century *magazine.*

CAN WE MEASURE THE EARTH?

Geodesy and Man's Voyage Beyond the Frontiers



Naturwissenschaftliche und Technische Sammlung Kassel

by Caroline Hartmann

A 2,250-year review of how man solved the paradox of measuring the unique, constantly changing spheroid on which we live.

How can we discern the shape of the Earth, without leaving its surface ? How can we exactly determine our location on Earth? How can we measure or otherwise exactly determine the distances among several locations?

The science of geodesy, and the closely related science of cartography or map-making, developed in the process of looking for answers to these questions. Today every nation has its own institutions charged with measuring its territory and producing exact maps, and we have arrived at a very high degree of precision. But the recent achievements of space research and of satellite geodesy have opened the way to ever more areas of research and ever greater precision—for example, the much more precise study of the differences in altitude on the Earth's surface, especially the huge ocean surfaces (ocean geodesy), which confront us with totally new questions.

Today we can determine positions on Earth with a precision of millimeters, using the Global Positioning System developed by U.S. military engineers. This technology, combined with wireless transmitters, makes it possible to steer large ships along rivers with precision, or to direct trucks across the vast expanses of a continent, or to locate leaks in oil or gas pipelines.

But, to return to the basic question: How were we first able determine the Earth's form without these modern instruments, and how has mankind produced ever more precise methods of measurement? This development has not been a smooth or linear process. After the first attempts, made by the members of the school of Alexandria in ancient Egypt, who recognized the Earth's spherical form, 2,000 years went by without any significant progress. During this time, man had to overcome many fundamental "limits" of his thinking:

The repetition theodolite produced by S.W. Breithaupt in 1829, with an 18-inch telescope, allowed for very precise geodetic measurements.

First, he had to recognize, that the assumption that he is on a plane surface presents him with unsolvable paradoxes and cannot be right.

Second, he had to find solid evidence for the fact that the Earth is indeed a sphere (or a spheroid).

Third, he had to recognize that the Earth's sphere, unlike a plane surface, incorporates the phenomenon of "curvature in the small," and another principle of our universe, perpetual change.

Now, how can we measure this unique, perpetually changing spheroid?

Measuring a Distance—Easier Said Than Done

It is not so easy to measure a "straight" distance, because we are always operating on a curved surface. On a sphere, it is difficult to measure lines. Yes, we can claim a stretch of land, like a garden or a field, by walking straight for a few yards, then going a few yards to the left, then back, parallel to the first distance, and then a few yards back to where we began. Done! So, some might argue, "What do we need a geodetical service for?"

But if a mayor of a city or a governor of a state wants to know its area exactly, or if a sailor wants to know the exact position of his ship, he has to know the "true" distances between several locations on the Earth's sphere. For, the larger the area we have before us, the more we cannot avoid the question: What *is* straight? Do I move precisely to the north, or by how many degrees to the northwest, and so on?

Some might argue that a compass will suffice. But, even if we follow a compass direction "straight," the conditions of the path will produce an imprecision too large even for us to determine the length of the path. We follow a compass, say, to the north. First, we have to remember always to take steps of the same length. So, we need a measuring rod. If we arrive at

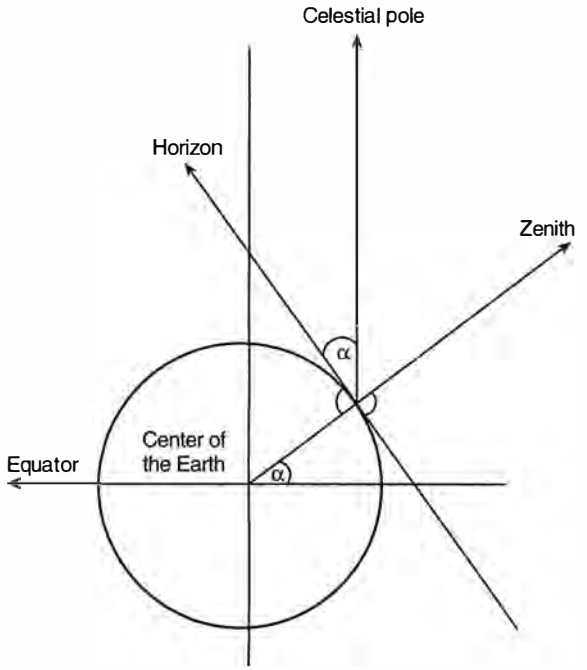


Figure 1
DETERMINING THE LATITUDE

To determine the elevation of the celestial pole α, and thereby the geographic latitude, the theodolite is fixed horizontally; then, through the telescope, one aims at the celestial pole. The angle between the horizon (the line perpendicular to the plumb line) and the celestial pole, is the desired value. The drawing shows that this is the same angle as the one between the direction of gravity, that is, the zenith of the observer, and Earth's equator.

At the North Pole, α = 90°. At the equator, α = 0°.

a river, we cannot continue, unless it is shallow enough to wade across. Otherwise, we have to take a boat. But then, how will we measure the *exact* distance, and how do we know that we continue our course *exactly* on the opposite side of the river?

After a while, we may arrive at a mountain. Even the slightest step above the surface of the river creates an uncertainty in measuring the distance; but when we cross a mountain, we have a difference of height as well as a difference in horizontal distance. The question arises: Which distance do we really want to measure, in order to define the distance between two locations? The "walking" distance, or the "true" distance, as if on the ocean's surface? If we want to produce a map, we will have to use the latter—or we would probably never arrive at the second location.

Therefore, geodesy never uses "direct" measurements of distances on Earth; it uses the method of triangulation. This method, described in detail below, was discovered by the Dutch mathematician and astronomer Willebrod Snell van Royen (1591-1626), and it was a giant step for man in measuring the Earth's shape, independently of man's sense perceptions.

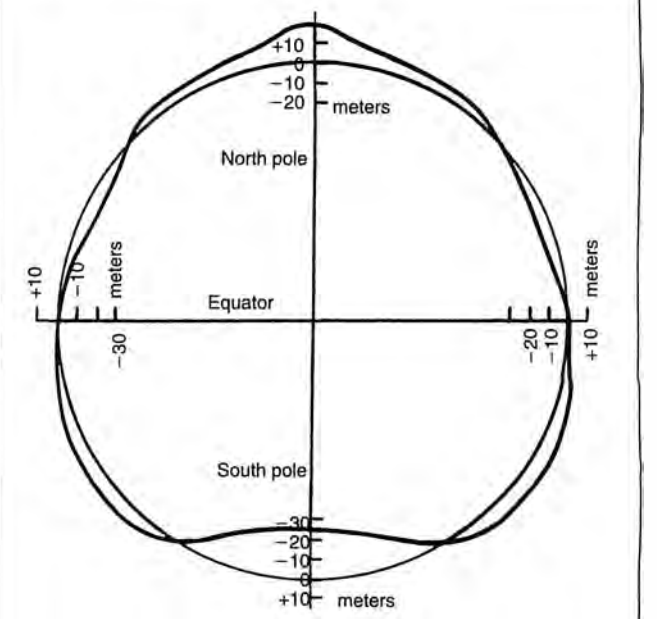


Figure 2
THE SHAPE OF THE EARTH

Satellite measurements show the deformations in the Earth's form.

Where Am I?

Determining a precise location or position on the surface of the Earth is as difficult as measuring the distance between two locations. What if we were the survivors of a plane crash in the middle of a desert? Of course, we would want to find to shortest way to the next human settlement. How could we do it? To help guide themselves, the members of the school of Alexandria, like Hipparchos, divided the Earth, as they had divided the sky, into precisely defined areas. They used lines like meridians (circles of longitude), where the Sun, for all points along these lines, reaches its highest position at the same time, and they used circles of latitude, where the angle between the horizon of the observer (the line perpendicular to the plumb line) and the direction of the celestial pole (which is parallel to the Earth's axis) is the same for all points along the circle.

But how can we determine *exactly* where we are? In order to do that best, we have to first determine our distance from the nearest pole of the Earth (that is, in the north-south direction), and, second, we have to determine our distance from a certain position defined as zero in the east-west direction. The first measure is our geographical latitude; the second, our geographical longitude.

Because a great circle has exactly 360°, it is better to measure these distances in angles, for, as we shall see, it is not easy to determine the exact length of an arc. It is possible, however, to measure the angle with an instrument (a quadrant or a theodolite), and thus to determine our position. How do we do this?

First, we determine latitude, which is, as shown in Figure 1, the angle between the horizon of the observer—perpendicular to the plumb line—and the line pointing to the celestial pole.

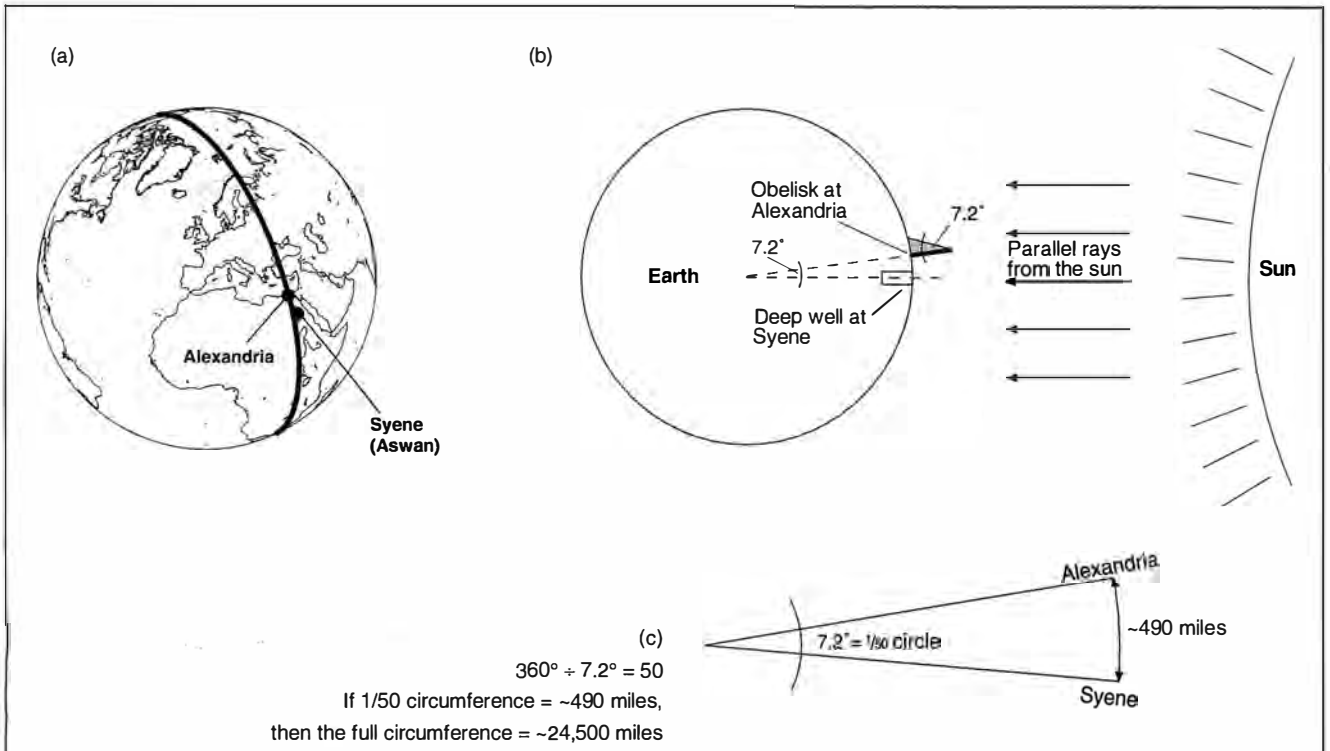


Figure 3
HOW ERATOSTHENES DETERMINED THE CIRCUMFERENCE OF THE EARTH

(a) The cities of Alexandria and Syene (Aswan) lie nearly on the same meridian, about 490 miles apart. (b) At the summer solstice, sunlight falls perpendicularly into a well at Syene; at Alexandria, however, on the same day, the Sun casts a shadow from the summit of an obelisk at an angle of 7.2°. (c) With a simple calculation, Eratosthenes arrived at an astonishingly precise result.

Longitude is the angle between the meridian line of the observer and the meridian line at Greenwich, England. Measuring longitude was still an unsolved problem in the 18th century. Because the difference in longitude between two locations is equivalent to the difference in local time, it is often stated in terms of hours, minutes, and seconds, instead of degrees. Until 1630, every country calculated its own time according to the line of meridian of the country's capital. Only since the end of the 19th century has the meridian of Greenwich been generally accepted as the 0° point.

Thus, in principle, we have to be able to determine the time that passes until a specific astronomical event occurs for the observer, compared to when it occurs at the zero meridian. We know, because of the rotation of the Earth about its axis, that the the moment in which the Sun reaches its highest position occurs 4 minutes later or earlier, for every 1 degree in east-west direction.

In all these considerations and possible measurements, we have implicitly presumed that the Earth is a perfect sphere. However, our measurements will not be perfectly accurate: As Christiaan Huyghens demonstrated in the 18th century, the Earth is not a perfect sphere, but is flattened toward the poles (a spheroid). This flattening causes differences in the determination of latitude.

Today, one can see in satellite pictures that the Earth is not even a perfect rotational spheroid: At the poles, it has "dents" of different sizes, and looks rather like an apple (Figure 2). The South Pole is about 25 meters closer to the plane of the Equator, and the North Pole is about 20 meters farther away from the Equator than it would be in a perfect spheroid. Ever since Carl Friedrich Gauss (1777-1855) described the Earth's form as a "geoid," the surface of which is defined as being perpendicular to the direction of gravity in every location, it has been evident that these deformations are of a fundamentally different nature from the unevenness of the mountains and valleys on the Earth's surface.

From Sensory Perceptions to Exact Proof

Now, let us look at some of the steps which led to the recognition of the Earth's true form.

The hypothesis that the Earth was spherical was held by the Pythagoreans in ancient Greece. They believed in a harmonic ordering of spherical planets, including the Earth; in this ordering, the planets were conducting a circular dance, at distances determined by the musical intervals. There were several problems, however, in really understanding the spherical form of the Earth—problems which could not be solved with the Pythagoreans' way of looking at things, which was based on everyday experience. In honesty, many of us today would find it difficult to explain these paradoxes:

• First, there is the question of the people on the opposite side of the Earth. If I stand with my feet on one side of the

sphere, does that mean that those on the other side must stand on their heads? But those on the other side of the sphere will say that they are standing upright. How can it be that one and the same direction is "up" for the one and "down" for the other?

• Second, it could not be explained how the many parts of the Earth were held together, especially the huge amounts of water in the oceans. Therefore, a real proof of the spherical form of the Earth was necessary.

Eratosthenes (circa 276-192 B.C.), a scholar of the school of Alexandria and head of its famous library, was the first to liberate himself from the notions determined by mere sense perception in looking at the universe; he constructed a real proof for the spherical form of the Earth, measuring what he could not see. Friends—possibly some of the last followers of the Pythagoreans—had told him about a well in Syene, Egypt (now the city of Aswan), where the Sun shone down to the bottom of a well on that summer day when it reached its most northerly position in the sky, the summer solstice. On this day, therefore, in Alexandria, Eratosthenes measured the angle of a shadow cast by an upright measuring rod that was exactly perpendicular to the Earth. Because the distance between Syene and Alexandria was known, Eratosthenes calculated the circumference of the Earth as being in the same relation to this distance, as the angle cast by the measuring rod's shadow would be to a full circle of 360° (Figure 3).

Eratosthenes' proof was a revolution for humanity—determining practical knowledge about nature which was inconceivable before these Greek scholars. Man's power of imagination had risen above all phenomena supposedly stemming from "logical" deliberations, based on pure sense perceptions; Eratosthenes had reached a higher level of knowledge.

Nearly 2,000 Years to the Next Step

At that point, one would have expected a rapid development in many areas of science and its applications. Instead, Eratosthenes' discovery was cast aside for many centuries. It was only in the 16th century, that this knowledge about the true form of the Earth brought to the fore again—about 2,000 years later! As late as 1580, the geographer Conrat von Ulm spoke merely of "geodaisia, which is of reliable and proven measurement of fields."

This extreme step backward in the effort to determine the true form of the Earth was related, most of all, to the decline of science during the time of Roman domination and the following centuries, which were dominated by oligarchical powers and interests. True, there were scientists who tried to propagate the knowledge of the school of Alexandria, like Isidor of Seville and the Venerable Bede. But cults, superstition, and mysticism, which were used by the oligarchy for social control, dominated the minds of most men. The cult of Apollo, which operated as a well-organized secret service, is one such example.

Further, independent scientific thought was stifled by the cultivation of Ptolemy, in second century A.D. Alexandria, who systematically falsified the discoveries made up to his time. For example, Ptolemy used the imprecise values given by Strabo, an astronomer with a back-to-nature outlook, instead of the much more precise measurements of Eratosthenes. This meant that measurements of longitude came out about one third too small, the Equator was too far north, the Mediterranean Sea was too long by 50 percent, and Asia was pushed east by 50 degrees! In his *Almagest,* Ptolemy had presented the ideas of Hipparchos and Eratosthenes, but in his second work, the *Geographic Introduction to the Representation of the Earth,* he turned around and used the wrong values given by Marinus of Tyre and Posidonius. He mentions an observing instrument that he supposedly constructed, but he may never have used it—he never explains how. In his *Geography,* the measurement of the Earth is explained only in principle, without any figures being given.

The Romans were hardly interested in the true form of the Earth or any other scientific endeavors. Theirs was a society in which scientific advance was "unnecessary," because bondsmen and slaves were available to do the work. They were interested only in claiming areas they had conquered, and the extension of existing forms of agriculture. In order to make these claims, the Roman surveyors defined an east-west line, called the "decumanus," and a noon line, the "cardo," by which they divided a given area. The land was measured with the aid of long roads, between which they cut right triangles. But these angles were never measured, and one can imagine how "parallel" the roads were, in reality. The Roman method of measurement was totally linear. It is no wonder, then, that their ideas about the Earth's form soon became similar to that held by the Egyptians in the 4th century B.C. (Figure 4).

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The Alexandrian astronomer Hipparchos, depicted with his astronomical instruments.

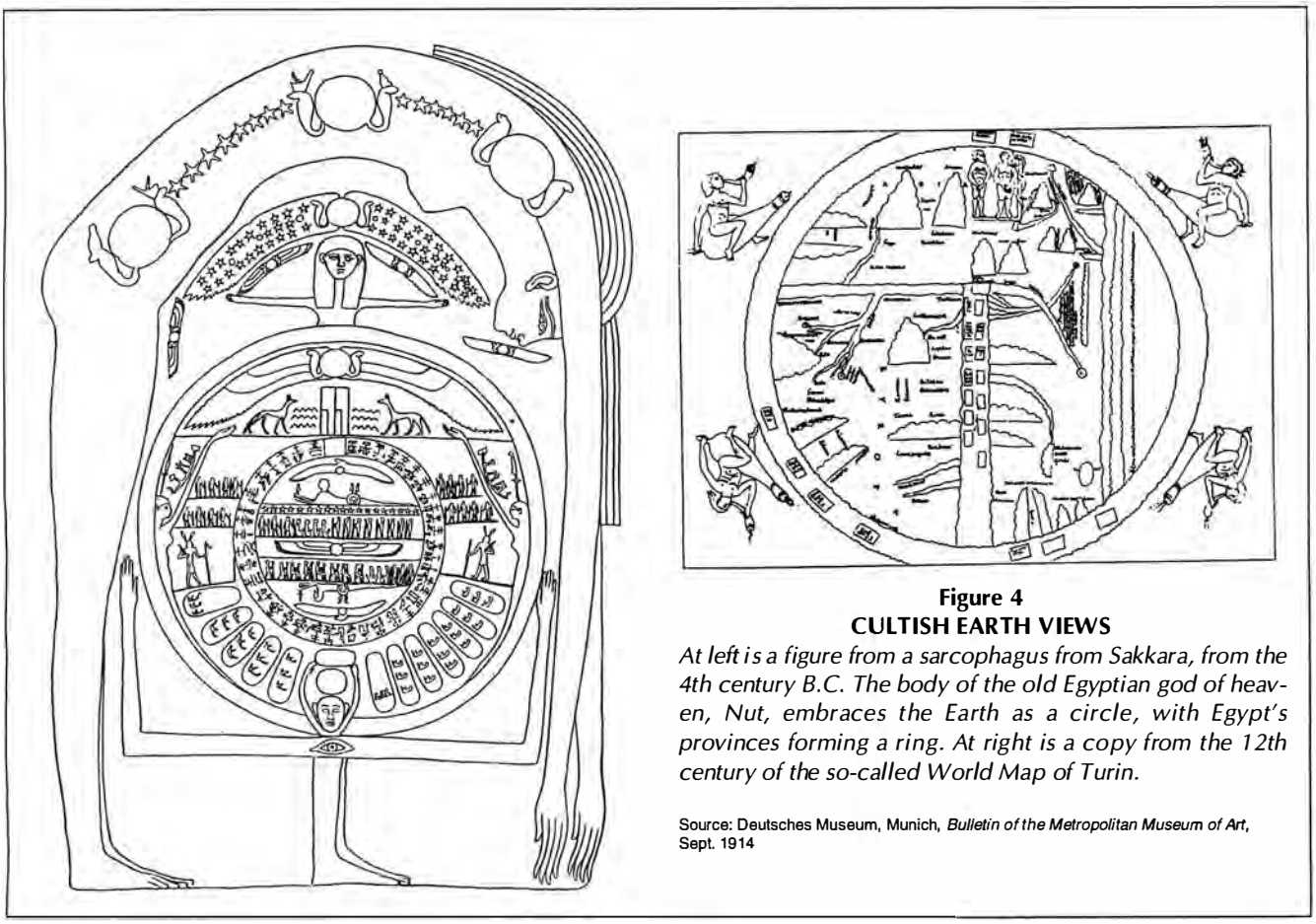


Figure 4
CULTISH EARTH VIEWS

At left is a figure from a sarcophagus from Sakkara, from the 4th century B.C. The body of the old Egyptian god of heaven, Nut, embraces the Earth as a circle, with Egypt's provinces forming a ring. At right is a copy from the 12th century of the so-called World Map of Turin.

Source: Deutsches Museum, Munich, *Bulletin of the Metropolitan Museum of Art*, Sept. 1914

Only after the compass was developed, and navigation was able to move beyond coastal shipping, did the question of the true form of the Earth come up again. As early as the 13th century, some seafarers intended to find a transatlantic route to India. But without reliable maps, this was a journey to no-man's-land.

Navigation and the Development of Cartography

To go from the recognition of the Earth's spherical form to a real understanding of the unique form of the Earth, requires another necessary step, which can be taken only if we really want to "discover" this sphere. It was Nicholas of Cusa (1401-1464), the scholar and cardinal, who demonstrated for the first time, in *De Circuli Quadratura* (Quadrature of the Circle), that it is impossible to define the real magnitude of the circumference of a circle, using a linear measuring unit. Thus, Cusa created a higher level of understanding of geometry. He taught that the Earth was a sphere, rotating around its own axis. Further, he drafted the first reliable map of Central Europe, and a map of the Earth, which was printed after Cusa's death as a copper engraving, one year before Columbus discovered America.

How closely the development of the production of maps was related to geodesy, and to the discovery of the true form of the Earth, is demonstrated by the work of two other scientists: the mathematician, astronomer, and mechanic Regiomontanus (Johannes Mueller of Königsberg, 1436-1476), and his student, the mathematician and seafarer Martin Behaim of Nuremberg (1459-1507), whose research and discoveries were studied closely by the founder of triangulation, Willebrod Snell.

As seen above in the determination of latitude, the measurement of angles is indispensable for the determination of a position on Earth. Drawing an "image" of a small section of the Earth, as Cusa did for Central Europe, an additional question arises about the true distances between two locations. Can we measure the angles here, too, instead of measuring the distances, which will necessarily be difficult and imprecise? How do we do this on a sphere? Or, graphically, if we draw a square on a deflated balloon, and blow it up, what happens to the square? Will the angles at the corners still be 90°? Or, vice versa, how do we represent a figure on the curved surface of the balloon—or of some area on Earth—on a plane sheet of paper?

For these questions, the works of Regiomontanus are of great importance. He was the first to explain the method of measuring angles and of calculating the relations between the angles and sides of a triangle, in his work *De Triangulis Omnimodis libri quinque* (Five Books on Triangles of All Kinds), and thus created a true science of the "trigonometry" of plane and spherical triangles. Figure 5 gives an example of Regiomontanus's approach.

Further, he was the first to accurately calculate the positions of comets, with instruments that he had developed. His student, Martin Behaim, brought Regiomontanus's astrolabes and

ephemerides to Portugal, where he stayed from 1484-1486. Christopher Columbus and Vasco da Gama both had his *Ephemerides ab anno 1475-1506* on board, and, using them, Amerigo Vespucci determined the geographical position of the mouth of the river Orinoco. Back in Nuremberg, Behaim created the first globe, a complete image of the Earth in spherical form.

The Problem of 'Curvature in the Small'

It is a unique property of a sphere, as opposed to a cylinder, that it cannot simply be unfolded onto a plane surface. There is no linearity, and every attempt to represent a section on a plane surface or map, will necessarily embody distortions. This phenomenon was studied more deeply only later, with the definition of the term "Gaussian curvature."

Ocean maps were, until about 1400, only plane maps, which did not represent the true relationship between longitudinal and latitudinal distances. Only when methods of projection were developed, primarily by Gerhard Mercator (1512-1594), in 1569, was significant progress made. In Mercator's projection, sometimes called "projection of the growing latitude," the Earth's surface projected by means of rays emanating from the center of the Earth, onto a cylinder enclosing the Equator. Thus, an image is created, which is significantly distorted in relation to the sphere, but is "true to the angles" in the small (Figure 6). If two lines cut each other in a specific angle on Earth, they will cut each other in the same angle on the projected image. Only the polar areas cannot be represented with this method, since the lines of latitude grow rapidly and ultimately to the infinite.

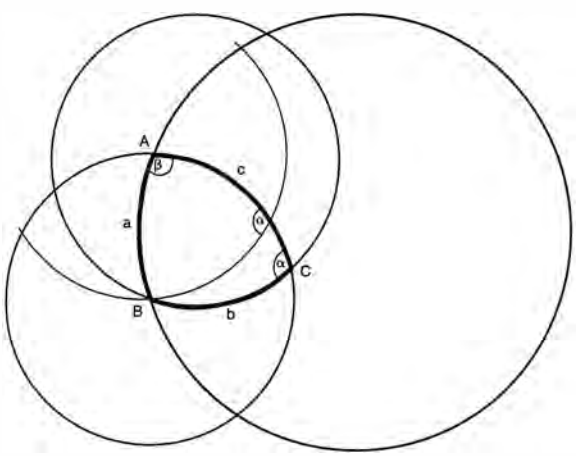


Figure 5
REGIOMONTANUS'S APPROACH TO GEOMETRIC MEASUREMENT

This is example 35 from the third book of De Triangulis Omnimodis libri quinque by Regiomontanus, where he discusses the spherical triangle ABC: "In every two spherical triangles, whose sides are equal except one of them, the angles lying opposite to the equal sides are equal." Regiomontanus's five books deal with plane triangles in books 1 and 2, and spherical triangles in books 3, 4, and 5.

Mercator's projection was a large step forward for seafaring. The explorer Magellan was the first in modern times to seek to prove empirically, that the Earth is a sphere, by his journey around the world from 1519-1521. This endeavor, which he himself did not survive, gained much attention.

First Attempts to Measure the Globe

A decisive impulse for the development of the science of map-making came from the attempts made to scientifically prove the Earth's form. Among the first who attempted to measure the latitudinal degree directly, was Jean-Francois Fernel (1497-1558), a French doctor. In 1528, Fernel described in his "Cosmotheoria," how he measured the latitude of 48 degrees, 38 min, in Paris, and then travelled a certain distance toward another place, four days away, counting the turns of a wheel of known circumference. This second location was chosen in a way, such that the difference in latitude could be calculated to be 1°, using the Sun's height at noon and its declination. Discounting a certain amount—without giving a detailed reason—he arrived at an arc's length of 1° = 101.1 km.

Because of Fernel's imprecise measurement of the Sun's height, his measurement was taken as a lucky accident. Snell said openly that he suspected fraud. Again, the obvious problem was the direct measurement of the distance, which necessarily made the endeavor a failure.

Noteworthy, too, is the attempt of Regnier Gemma Frisius (1508-1555), which is often erroneously called a triangula-

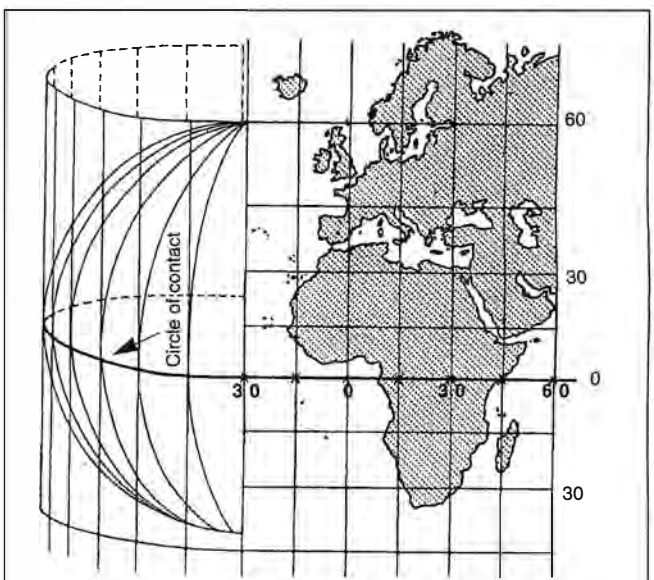


Figure 6
MERCATOR'S PROJECTION

The projection of the Earth's sphere onto the surrounding cylinder. By this projection, the distances between the latitudinal circles get larger, as one moves away from the equator. Near the poles, the distances grow to the infinite. As a result of this distortion, Mercator's projection is used mainly to depict the areas between 50° north and 50° south; the projection preserves the angles.

tion. Gemma Frisius defined a so-called basic distance between the church steeples at Brussels and Antwerp. Using a circular disk marked in grades, similar to a quadrant, he determined the line-of-sight to additional locations. These disks were oriented exactly to the north, by means of a compass. Then the points of intersection of these directions were graphically determined on a sheet of paper. From these locations, Gemma Frisius continued in the same manner, "cutting forward" new points of measurements (Figure 7). The weak point of his method is, that the length of the basic distance is not known. The line from Brussels to Antwerp was the basis for the calculation of all the other distances, but Gemma Frisius never measured how long this distance actually was; he just took it as given.

The Discovery of Triangulation

It was the Dutch mathematician, astronomer, and cartographer Willebrod Snell, who discovered how to free himself from measuring distances directly on the Earth. With his measurement of the length of the arc of 1° between the locations of Bergen op Zoom and Alkmaar in the Netherlands, he introduced a highly precise method—*triangulation*—instead of estimating or imprecisely measuring the length of an arc of 1° on Earth directly.

In his two-volume work *Eratosthenes Batavus—De Terreni ambitus vera quantitate* (The Dutch Eratosthenes—On the true magnitude of the Earth's circumference), Snell argues that he wanted to measure the Earth's circumference in a more precise way than Eratosthenes did. His presentations and calculations are based on real measurements, which could be verified.

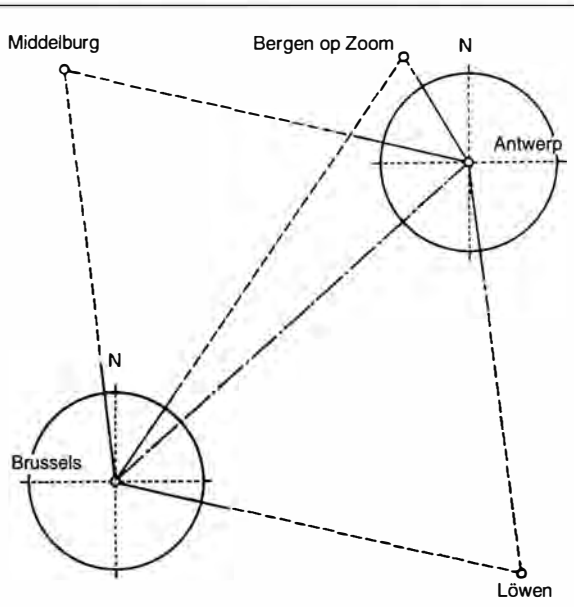
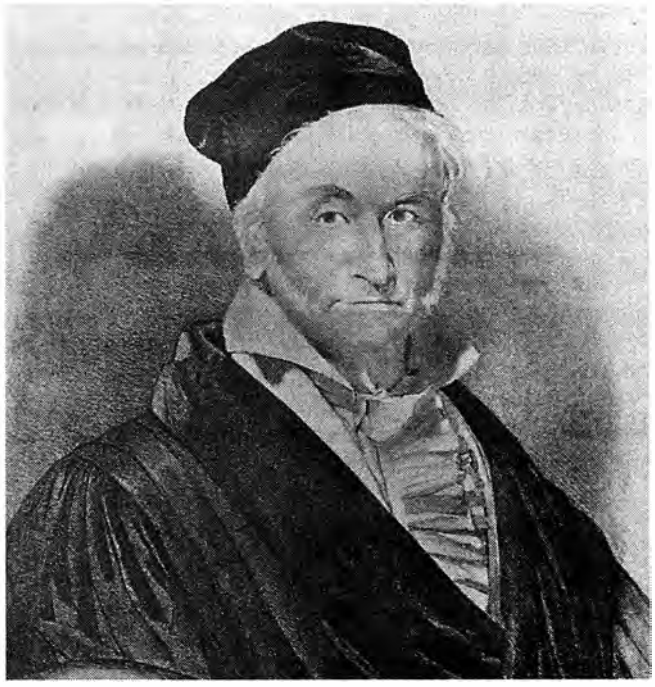


Figure 7
GEMMA FRISIUS'S METHOD OF 'CUTTING FORWARD'
This method devised by Regnier Gemma Frisius can be used to produce maps, but it does not measure true distances.



Carl Friedrich Gauss (1777-1855)

As can be seen in the earlier attempts described above, the measurement of straight distances on the Earth poses insurmountable difficulties. Hero of Alexandria, for example, circa 3rd century A.D., noted in his *Dioptria,* that there is no good measuring if there are mountains or valleys or even oceans in between. But even along shorter distances of a few kilometers, there are many irregularities. Also, the material of the measuring rods or lines can be distorted by changes of temperature or moved by wind, which will prevent the necessary precision.

Even the method of measuring distances by measuring the angle of the Sun with a rod perpendicular to the Earth (the method of Eratosthenes) was considered too imprecise by Snell. Pointedly, he noted that Eratosthenes should not have assumed that the Sun's rays are parallel, because the Sun is very large, and the rays emanating from different sides of the Sun will arrive at slightly different angles.

Regiomontanus had written several seminal works on the perfection of trigonometry,including *De docta triangulorum* and *De triangulis omnimodis libri quinque* (Nuremberg 1533), which dealt with the possibility of calculating angles and triangles. He calculated the first detailed tables of the sines for the unit radius of 60,000, for angles up to 90°, and another more complete table of sines for a radius of 6,000,000. He also introduced the *versine* ($1 - \cos \alpha$), although he did not use that term himself.

Snell had thoroughly studied Regiomontanus's works, before he considered triangulation as a method to measure the Earth using plane trigonometry. Regiomontanus explained all relations and lawful connections within plane and spherical triangles, using the circle, the sphere, and their movements. Thus, a new understanding developed, that triangles actually are "created" by a number of circular movements, an under-

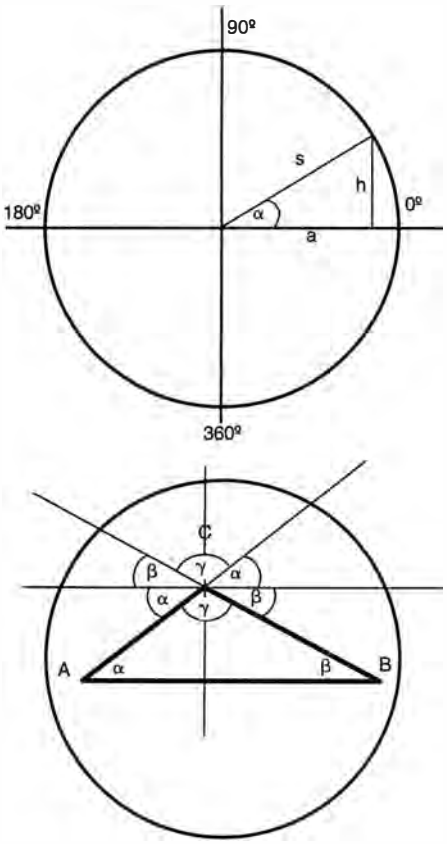


Figure 8
THE TRIANGLE AND THE CIRCLE

The trigonometrical functions are represented by the sides of a Pythagorean (right) triangle:

(1) sin α = h/s = opposite/hypotenuse
cos α = a/s = adjacent/hypotenuse.

(2) The sum of the angles of a plane triangle will always be 180°. Triangles and the relationships among their sides and angles can best be explained by circles. Because the circle's circumference will always be 360°, it can easily be shown by parallel displacement, that α + β + γ = 180°.

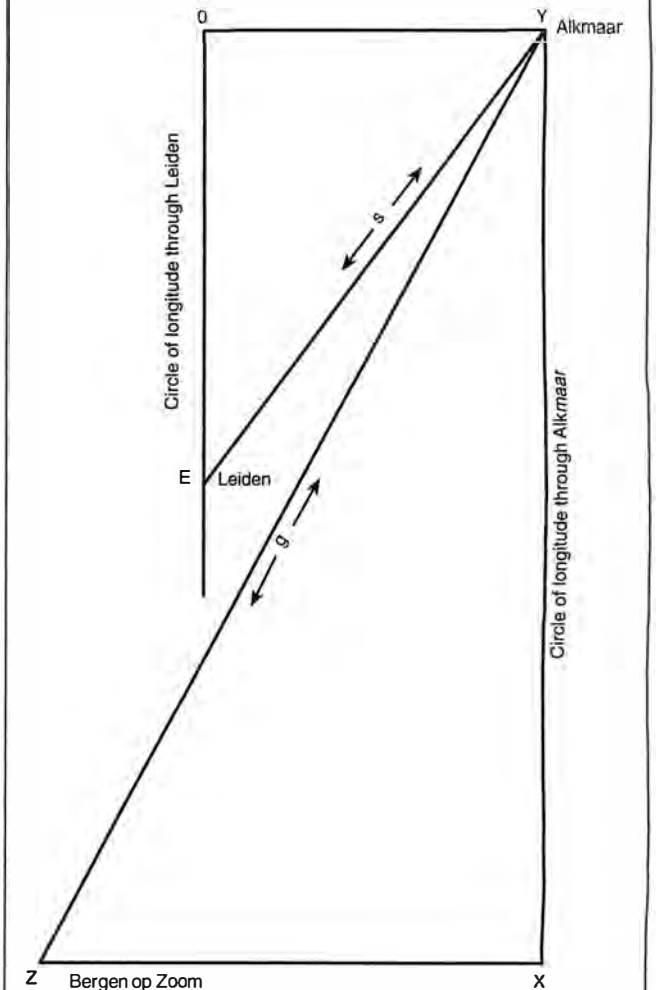


Figure 9
THE GEOMETRY BEHIND SNELL'S TRIANGULATION

According to Pythagoras's law,

$g = \sqrt{XY^2 + ZX^2}$, and

$s = \sqrt{EO^2 + OY^2}$.

standing which has since been lost. In the classroom, triangles are presented as static constructs of linear geometry, and their laws are taught as dead formulas. What is actually interesting in triangles, is their close relation to the circle, and thus to the trigonometrical functions—the inner relations of which (Figure 8) have been forgotten and thus mystified in what is taught today.

Snell's drawings in *Eratosthenes Batavus* demonstrate how fascinated he was that his method could determine the precise location of some point on Earth, measuring the angles and calculating their sides. Further, he collected all the astronomical observations of Regiomontanus, and published them in 1618, together with those of Bernhard Walther and William IV, count of Hesse-Cassel.

Thus, Cusa and Regiomontanus defined the tradition of thought, which Snell followed in devising his method to measure distances *indirectly*. With this method, he liberated geodesy from measuring distances *directly* on the Earth's surface, and from all methods resting on pure sensory perceptions.

Now, let's look at how Snell determined the true distance between two latitudinal degrees, because it was in fulfilling this task, that he developed the original method of triangulation. It is this mere by-product of the above task, which is used still today (although in a form refined by Gauss and others) to exactly measure the form of the Earth.

Snell's strategy was as follows:

First, he wanted to find two locations in the Netherlands, which were exactly 1° apart in their geographic latitude. Determining the geographic latitude of Alkmaar and Bergen op Zoom, using the method described earlier, he found that Alkmaar is exactly 1° north of Bergen op Zoom. But in order to determine the true length of the arc of 1° (distance *YX* in Fig-

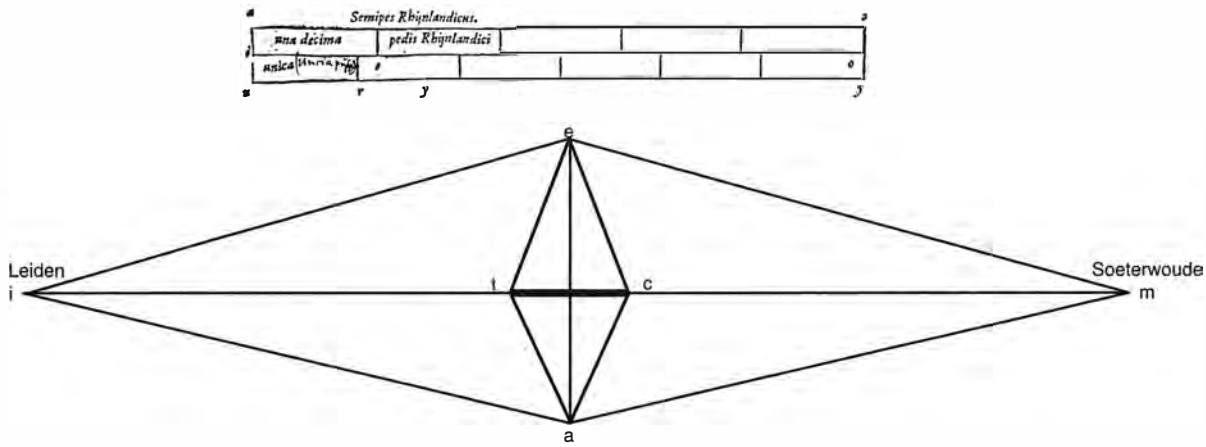


Figure 10
SNELL'S METHOD OF ENLARGING THE BASELINE

Snell used Rhenish wooden measuring rods (see his drawing above) to measure out a very short distance of a few meters. This is the baseline, with the end points t *and* c. *From these positions, the points* e *and* a*—for example, widely visible towers—are chosen, such that the angles* etc *and* ect *can be measured by a quadrant or a theodolite. From the laws for plane triangles, Snell could calculate the angle* tec *and the sides* ec *and* et. *In the same way, the triangle* tac *is determined. The angle* eta *is obviously*

$$\text{eta} = etc + cta,$$

and, because the two sides et *and* at, *and the enclosed angle* eta, *are known, Snell could calculate the distance according to the law of cosines developed by Regiomontanus:*

$$\text{ea} = \sqrt{te^2 + ta^2 - 2 \cdot te \cdot ta \cdot \cos \sphericalangle eta}.$$

The distance ea *is now used as the new baseline, to calculate the large triangles* ema *and* eia, *which, following the same method, produces the distance between Leiden* i *and Soeterwoude* m, *which was the distance he sought.*

ure 9), he had to project the distance Bergen op Zoom-Alkmaar (*g*) onto the meridian of Alkmaar. To increase the precision of his calculations, he also looked at the meridian of the city Leiden, and projected the distance Leiden-Alkmaar (*s*) onto the meridian's section *EO*.

Now, Snell was dealing with two right triangles, *OEY* and *ZXY*. Using Pythagoras' law, he could determine the length of *XY*, which is equivalent to the length of 1° of latitude. These were his preliminary thoughts. Then, he had to "measure" the distances.

His next step was to determine 23 locations in the area between the two meridians through Alkmaar and Bergen op Zoom. Then, he looked for prominent, very visible features of these towns, like the steeples of churches or city halls, which he needed to take bearings on measuring the triangles. The distances between these towns were smaller than that between Alkmaar and Bergen op Zoom, but still too large to be measured directly. However, he had an idea on how to circumvent the direct measurement: He invented the principle of enlarging the basis, or baseline.

His first target for a real measurement was the small distance from Leiden to Soeterwoude. In order to carry out his plan, he indeed measured a short distance of several meters very precisely. Using a double row of wooden rods made especially for this task, he laid these rods out parallel to each other, as shown in Figure 10.

This small, precisely measured distance with the ends *t* and *c* was his baseline. It was not important whether this distance was on the line between Leiden and Souterwoude. Then, he marked two other points located a few meters to the right and to the left from the line *tc*, *e* and *a*, and measured the angles *etc* and *ect* from the end points of his baseline *tc*. Now, he looked at the triangle *etc* and calculated, according to the laws of trigonometry, the angle $tec = 180° - (\sphericalangle etc + \sphericalangle ect)$. Further, he calculated the sides *ec* and *et* (because the side *tc* was known), as follows:

$$ec = tc \cdot \frac{\sin \sphericalangle etc}{\sin \sphericalangle ect}$$

and

$$et = tc \cdot \frac{\sin \sphericalangle ect}{\sin \sphericalangle tec.}$$

Thus, all sides and angles of the triangle are known. In the same way, he determined the lower triangle *tac*.

Obviously, the angle *eta* is the sum of the angles *etc* and *atc*, and now, the distance between *e* and *a* could be calculated according to the law of cosines in plane trigonometry:

$$ea = \sqrt{te^2 + ta^2 - 2 \cdot te \cdot ta \cdot \cos \sphericalangle eta}.$$

This is called the method of enlarging the baseline, because the relatively small baseline *tc* is measured directly, and then enlarged by the procedure described above. Because, this new distance *ea* is now used as the baseline for

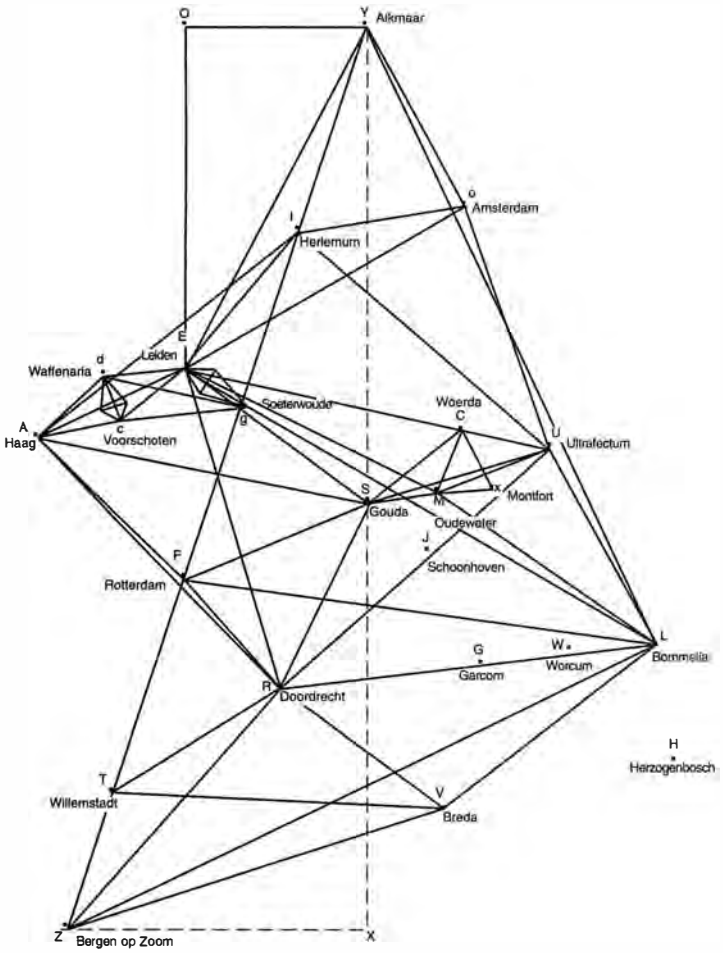


Figure 11
SNELL'S METHOD, USING 23 LOCATIONS
The network of 23 prominent towers in towns in the Netherlands chosen by Snell, and the marked distances between the individual locations, which he calculated using the method of enlarging the baseline.

the calculation of the larger triangles *aei* and *ame,* to arrive at the length of the distance *mi* (from Leiden to Soeterwoude).

This, however, was only the first step of his huge endeavor.

Next, Snell measured and calculated the triangle Soeterwoude (g)/Leiden (E)/Waffenaria (d), knowing the side *gE* from his first measurement, and determining the angles *Egd* and *gEd,* using his quadrant, to take bearings at the church steeple of Waffenaria (Figure 11). From the trigonometric calculations, he derived the sides *gd* and *Ed.* After calculating the triangles Vorschooten-Leiden-Soeterwoude and Leiden-Waffenaria-Vorschooten, where he again determined the distance Vorschooten-Waffenaria, using the method of enlarging the baseline, he then determined all the distances within the network Haag-Waffenaria-Vorschooten-Leiden, using the distance Vorschooten-Waffenaria as the baseline to determine the distance Haag-Leiden.

Thus, Snell created down, step by step, a network of small triangles, and came closer and closer to the great distance between Alkmaar and Bergen op Zoom (Figure 11). About the method of these many small steps, he wrote:

> I have taken the following path to solve the problem: differentiating the individual problems into several individual triangles, I could achieve the whole work speedily and comfortably [*Eratosthenes Batavus,* p. 169].

How Can We Measure an Angle?

The great paradox of determining the curved surface of the Earth using linear measurements, has now been reduced to a much more achievable task: measuring the angles between individual, fixed markings on Earth. But how can we measure these angles, really? For this, we use theodolites. In antiquity, Hero of Alexandria had constructed one of the best instruments to measure angles, which he called the *dioptra,* and from this, the modern theodolite was derived.

The main part of a theodolite is a horizontal circle (called limbus), which has been marked with utmost precision. In the center of this circle, is a telescope, which can be turned horizontally and has a pointer (called alhidade). The earliest theodolites did not have a telescope; one had to take bearings with the naked eye. The telescope was pointed to the apex of an object, and the angle was read from the horizontal circle. Then, the telescope was pointed at the second object, and the angle read again. The difference between the two angles was the angle being sought.

To increase the precision, the procedure can be repeated. Thus, we have measured the "horizontal angle" (Figure 12), that is, the angle between the points within the level defined by the horizontal circle of the theodolite. This horizontal circle is set exactly perpendicular to the plumb line, that is, the direction of the Earth's center, using a very precise leveling instrument.

The fact that a theodolite always measures the horizontal angle, is what distinguishes this instrument. For, if we take bearings at the steeple of a city hall, for instance, we get an inclined line up to the steeple, a horizontal line to the base of the steeple, and the height of the steeple itself, a vertical triangle. Taking bearings at the other object, we arrive at a similar triangle. The problem, that the angles between the inclined lines is not the same as that between the horizontal lines, does not concern us in measuring the horizontal angles.

In all these measurements, there are many sources of error, but with the development of fine mechanics, optics, telescopes, and the refinement of the scales on the horizontal circles, the theodolite gained unique importance in modern geodesy (see Figure 13).

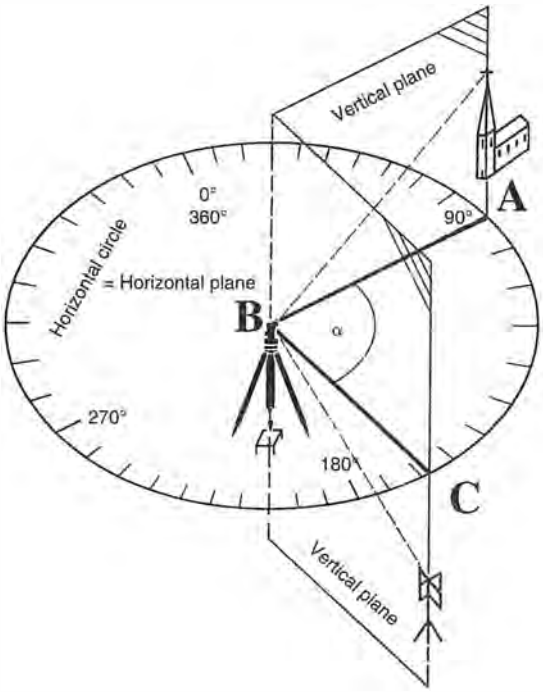


Figure 12
USING THE THEODOLITE

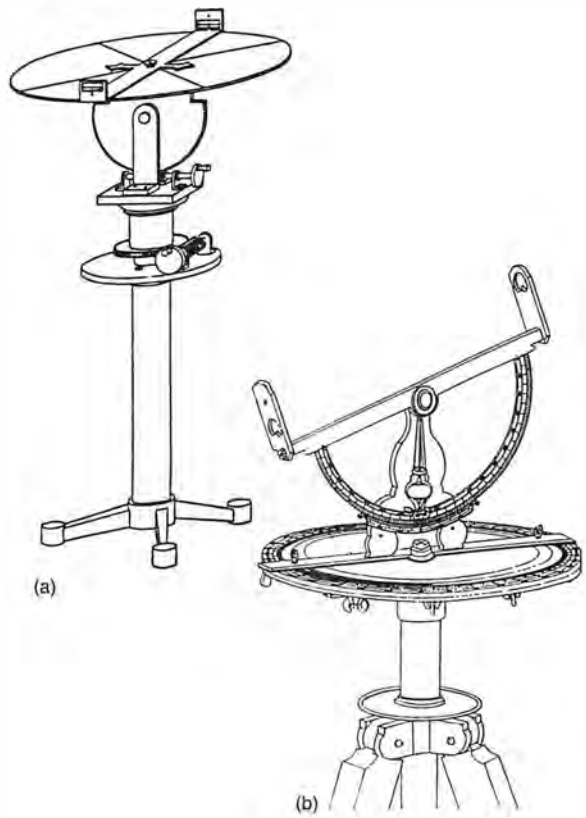
We want to measure the angle α, which is between the observer B, where the theodolite is centered and levelled out, and the two locations A and C. To make the measurement, we take bearings at point A and read the angle on the theodolite's horizontal circle (which is divided into 360 degrees); then, we take bearings on point C, and again read the angle on the horizontal circle. The difference between the two angles, is the angle α we sought. One can see, that because of the construction of the theodolite, only the horizontal angles are measured.

Today, in addition to the horizontal circle, the theodolite has a vertical circle, to measure the vertical angles; a telescope, which can be turned about the vertical axis and about the inclining axis; and installations to read the scale on the circles, and to orient the vertical axis precisely along the plumb line.

The rapid development of machine-tool building in the 19th century made ever more precise measurements possible. Among the companies that became famous for the precision of their geodetic instruments, in the latter half of the 19th and the first decades of the 20th century, we note the workshops of Carl Zeiss in Jena, Germany, where F.W. Breithaupt built the instruments developed by Reichenbach, of Otto Fennel in Cassel, and of Max Hildebrand in Freiberg/Saxonia; the works of R. & A. Rost in Vienna; and the companies Wild in Herrbrugg and Held in Aarau, Switzerland.

A Network of Triangles

When he had measured the first distance between Leiden and Soeterwoude, Snell devoted years to the measurement of



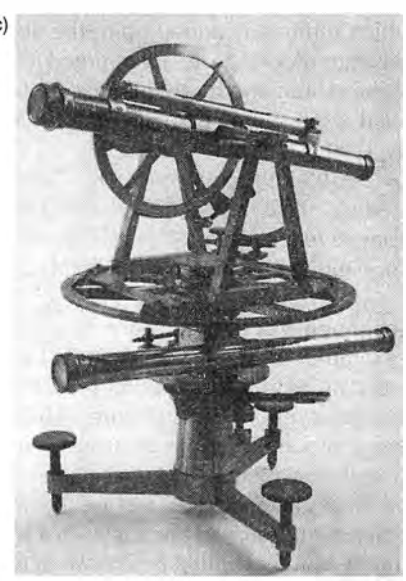


Figure 13
DEVELOPMENT OF THE THEODOLITE

(a) Hero of Alexandria's dioptra, about 100 A.D.
(b) An English diopter-theodolite, about 1650.
(c) A transit instrument by F.W. Breithaupt in Cassel, 1820, which can also be used as a multiplication theodolite.

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Willebrod Snell (1591-1626)

many individual small distances, using the method of enlarging the baseline, to create a network of 23 triangles in total (Figure 11), which ultimately added up to the distance from Alkmaar to Bergen op Zoom. Now, he returned to his original geometrical construction, and by calculating the two right triangles, he arrived at the value of the distance, which is equivalent to exactly 1° of geographical latitude:

1° = 28,500 Rhenish rods (= 107.3 km).

Now, he could calculate the circumference of the Earth, according to the simple relationship:

U : 107.3 km = 360° : 1°, where U is the total circumference of the Earth.

In his studies, Snell discovered more possible measurements, as, for example, the method of "cutting backward," to determine the distances to a fourth point from the given distances between three other points (Figure 14). This method later became very important for the great surveying projects.

The paradox in this method is, that we calculate triangles as if we were on a level surface; that is, we use the laws of plane trigonometry (such as, the sum of the angles in a triangle is always 180°); but, by closely knitting a network of triangles, we can measure the curvature of the Earth's spheroid.

Carl Friedrich Gauss was really the first one to study the small imprecisions in triangulation, which derive from the laws of plane trigonometry, and to seek improvements in the methods of observation and measurement. He once noted that the invalidity of the axiom of a sum of the angles of 180° would probably appear only in measuring the huge distances between the stars. Gauss was in constant contact with Reichenbach's workshop in Benediktbeuren, and he

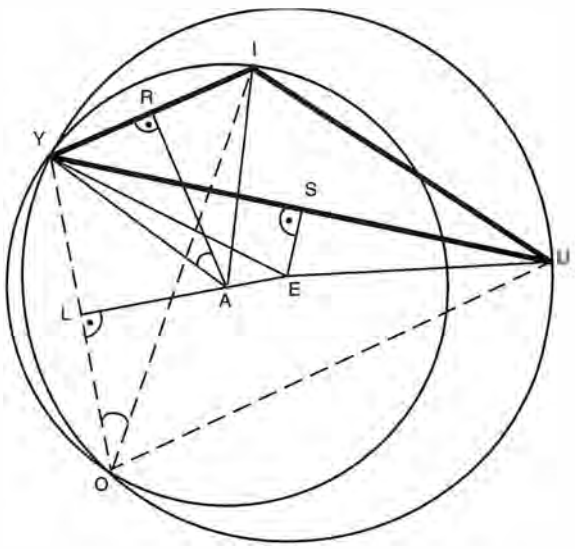


Figure 14
SOLVING THE SNELL-POTHENOT PROBLEM

Snell's method of triangulation solved the problem of "cutting backward," which is today known as Pothenot's Problem or as a "recession problem." (Correctly, it should be called the Snell-Pothenot Problem.) Hipparchos had already discussed the problem, that in order to determine the ephemeris of the Sun, we have to find the point near to the center of a given circle, where the rays to three known points on the periphery of the circle are perpendicular to each other.

Snell reformulated the problem: If the distances between three given points are known, the distances to a fourth point are also known, from which we can take bearings at the three other points, and measure the respective angles.

Snell is looking for the distance between O *and* I, *which he derived from the given distances between Y,* U *and* I, *and the angles* YOI *and* YOU, *which he measured. The geometrical construction he used, was the following: If one connects the bisectors of the angles over* YI *and* YO, *as well as over* YU *and* YO, *the point of intersection of the first two lines A is the center of the circle with the radius* YA, *on the periphery of which the point* O, Y *and* I *lie. Then, the radii result in*

$$YA = YI/(2 \sin YOI) \text{ and } YE = YU/(2 \sin YOU).$$

In the triangle AEY, *the two sides, and the enclosed angle are known, and thus also the angle* AEY. *Because* LE *is perpendicular to the center of* YO, *we can also calculate* YO:

$$YO = 2\,YE \cdot \sin AEY.$$

Then, we calculate OU, *in the triangle* OUY, *and* OI, *in the triangle* OIY. *Then, we know the sides* OY, OI, *and* OU.

visited him to discuss ideas and improvements.

The method of triangulation was first used in the survey of Württemberg (1624-1635), carried out on the personal initiative of the mathematician and orientalist W. Schickard of Tübingen. Although he had the cooperation of the duke's administration, he had to rely on the help of the population of the area. In order to determine the most visible landmarks, he called upon artists, scholars, and students, to inspect the area around their home towns, and to place their notes at his disposal, thus, fostering an eager interest in geodetic study.

The trigonometrical net was constructed exactly according to Snell's method. Close to the Neckar river, a baseline of 3,900 feet was measured, which then was used according to the method of enlarging the baseline. Points, which were located in narrow valleys, and could not be aimed at directly, were determined according to Snell's method of "cutting backward." For this great survey, Schickard constructed foldable, triangular instruments. Unfortunately, because of the Thirty Years' War, Schickard died very young, and the engravings for the maps could not be finished. Shortly after Schickard, W. Bachmayer used Snell's method, to measure the area of the free imperial city of Ulm.

The first great survey was done in France, in 1671, directed by the astronomer Jean Picard (1620-1682). In the illustration of his triangular network, the original baseline determined according to Snell's method of the enlarged baseline, is visible (*XY* in Figure 15). In his measurements, Picard was able to make use of many improvements in the instrumental technology. After the telescope had been developed in the beginning of the century, it was necessary to define the precise direction of aiming by fixed marks, lattices, or threads, in order to use it for these observations. In addition, these could be used to make fine movements visible against the rough division of the circle. Picard was the first to use reticules in his telescopes, made out of hairs or metal wires.

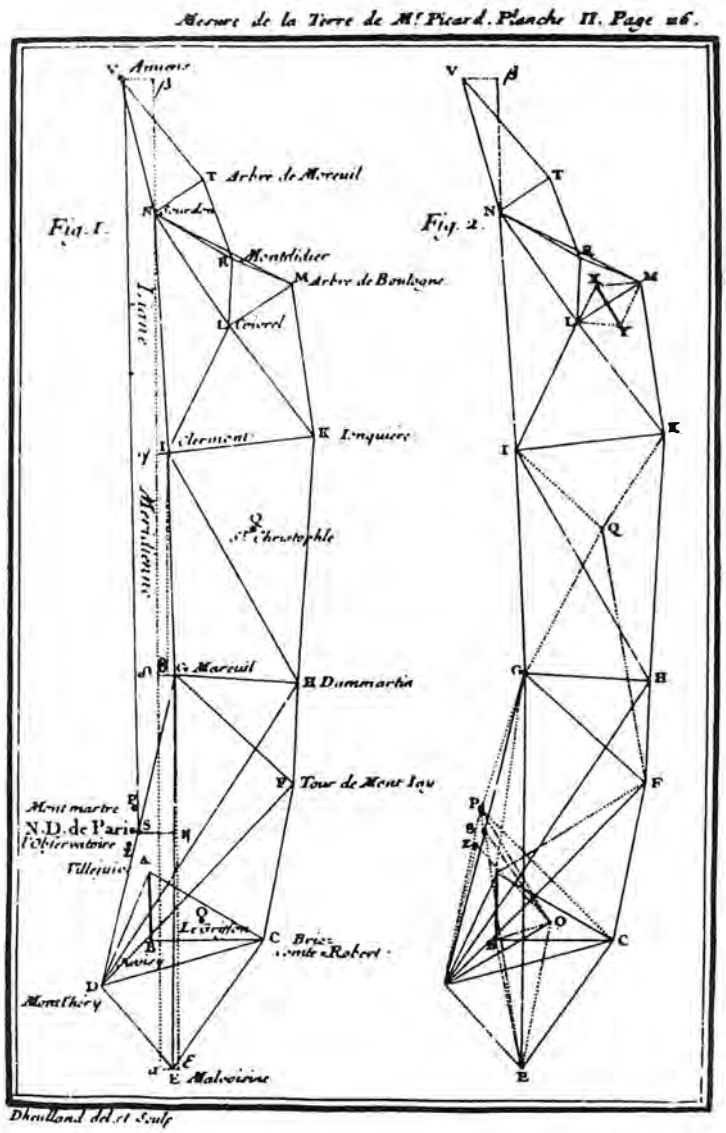


Figure 15
PICARD'S TRIANGULATION
The drawing on the left includes a fine line for the meridian. On the right, notice the baseline xy *near top.*

For triangulation, Picard determined the meridian's arc, as Snell had done, by a chain of triangles. Figure 15 indicates the fine line of the meridian, to the left, and the original baseline *XY,* to the right.

Following France's example, soon all European countries were surveyed for military, administrative, and other reasons. Countries beyond Europe were opened up through scientific expeditions like those of Alexander von Humboldt to South America and Russia. The first geographical and topographical map of France was produced in 1744 by Cassini de Thury. In Denmark, measurements started in 1766, in Saxonia in 1780, in England in 1784, and in subsequent years in other countries.

Real improvements of the method of triangulation, and of the theodolites and fine mechanics in general, were closely related to the geodetic and other works of Carl Friedrich Gauss. Gauss introduced a whole new era, in terms of conceptual profundity and precision. Gauss's work still stands today as a challenge to modern science, which has yet to complete the tasks he defined.

Caroline Hartmann is an organizer with the LaRouche political movement in Germany. This article first appeared in the German-language Fusion *magazine (April-May-June 1998), and was translated into English by Alexander Hartmann.*

ERATOSTHENES IN ACTION

The Decipherment and Discovery Of a Voyage to America in 232 B.C.

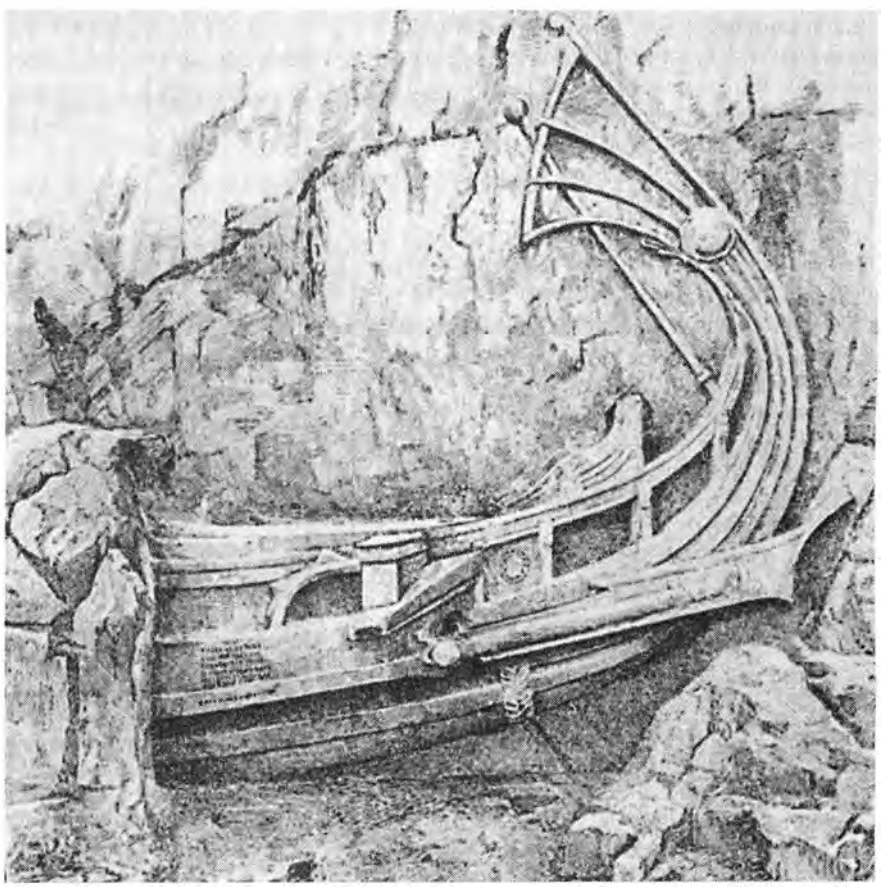
by Marjorie Mazel Hecht

About 25 years ago, marine biologist and linguist Barry Fell made a stunning breakthrough in deciphering inscriptions from the Pacific islands and from Irian Jaya, the western side of New Guinea, which is now part of Indonesia. Fell determined that the inscriptions were written in a western (Libyan) dialect of ancient Egyptian, and that this was the basis of the Maori language of the Polynesian islanders. The oldest of the inscriptions, found in the "Caves of the Navigators" in Irian Jaya, were dated to 232 B.C.

In the early 1970s, Fell, originally from New Zealand, was at the Museum of Comparative Zoology at Harvard University, where he had been working on his speciality of the biology of the ocean floor, and in particular echinoderms, since 1964. But he devoted much of his energy to epigraphy, enjoying the vast library resources on "obscure languages and writing systems" at Harvard. One of the many puzzles he tackled was the mystery of the strange inscriptions throughout the Polynesian islands—from Hawaii to New Zealand.

As he described it, he spent eight years, "ransacking" Harvard's Widener Library, to pursue his initial hunch that the Polynesian inscriptions were not meaningless scribbles, as the experts had maintained, but "a written form of the Polynesian language, and that the texts it perhaps concealed would possibly answer our hitherto unsolved problems of how American and Asian domesticated plants and animals found their way to Polynesia."

Fell had long pondered the fact that the hundreds of inscriptions on rocks and in caves throughout the Pacific Islands had similar characters, although they were located on islands separated by thousands of miles. He also had been impressed with something his zoology professor in graduate school in New Zealand had told him about the similarities between words in the present-day Maori language, and the classical Mediterranean languages. (Fell himself was an extraordinary linguist, with proficiency in many languages, including Maori and ancient Greek.)



Drawing of a bas-relief of an Egyptian warship, early 2nd century B.C., at the acropolis in Rhodes. From The Social and Economic History of the Hellenistic World, Vol. II *(Oxford: The Clarendon Press, 1941).*

Through perseverance, Fell's hunch became a reality: "Recognizable letter forms and words began to emerge," he wrote. Fell credits the academic atmosphere at Harvard at the time, for providing the "intellectual freedom" and the compatriots, including students, in his quest. "I doubt if a more favorable atmosphere for solving the problem could have been found in any other place," he wrote.

Among the Maori-language inscriptions, Fell determined that: "the older an inscription is, the closer its vocabulary is to that mixture of Greek and Egyptian that was once spoken in North Africa after Alexander conquered Egypt. The oldest of all the inscriptions proved to be written in ancient Libyan, a dialect of Egyptian spoken by the brown-skinned fisherfolk whom the Greeks called Mauri."

Some inscriptions, among the 1,500 or so known ones, were bilingual, with Latin or Punic as the second language (these are tomb inscriptions from Algeria and Tunisia), which provided clues. In general, the inscriptions were alphabet characters, with no vowels marked (as in Hebrew). Fell was able to recognize some root words in Egyptian and in standard Polynesian. In some cases, if the letters were substituted with their ancient Egyptian counterparts, the inscriptions could be read in Egyptian. A sense of how Fell worked at the puzzle can be seen from the sample Fell translation and his comparison of Maori alphabets that appear in the figures.

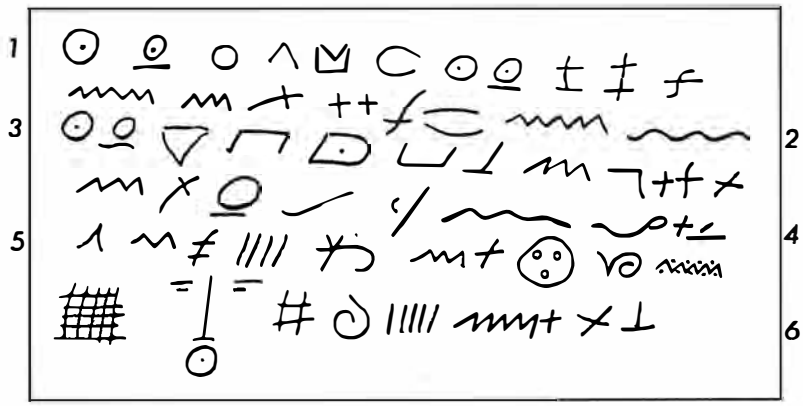


Figure 1
FELL'S RECTIFICATION OF THE SANTIAGO CAVE INSCRIPTION

The inscription, copied from a cave near Santiago, Chile, by Karl Stolp in 1885, is rendered here by Barry Fell. The script is standard Libyan, and reads alternately from left and from right. The language is ancient Maori, which Fell determined to be spoken in the western part of Egypt (Libya) as a dialect of ancient Egyptian. Modern Maori dialects, according to Fell, differ only in minor respects from the language of Maui.

Source: Reprinted with permission from the Epigraphic Society Occasional Publications, Vol. 2, No. 21. See Note 3.

Figure 2
FELL'S PHONETIC TRANSCRIPTION OF THE SANTIAGO TEXT

1. *Re Re-su ra ga Ma-wi. Ba re Re-su ta-za Te-te to-*
2. *hi ha-wa tu ta Ta tu-hi-ha.*
3. *Re Re-su za-wa da-ba ma-ka. Hi-ge ta Ta tu*
4. *Na-za Ta-m'ra Hi-ne Za zara tu ha,*
5. *ga-ʏa-ta-ta IIII da-ba ʏa-ta, ra-kha, wa-ra (mountain hieroglyph)*
6. *ka-ta. Ta-he IIIII-ra ni-ta ra-na-pa 16.*

Source: Reprinted with permission from the Epigraphic Society Occasional Publications, Vol. 2, No. 21. See Note 3.

Upsetting the Establishment

Deciphering Maori was just one of Fell's many wide-ranging discoveries.[1] During his years at Harvard, he pioneered other epigraphic work, mostly around ancient (pre-Columbian) inscriptions and settlements in America. He published three books on the subject, the best known of which is *America B.C.*, and created "earthquakes" in the traditional disciplines of archaeology, epigraphy, and ancient history (to name just a few). To this day, it is considered academic heresy to agree with Fell, and his departure from Harvard in 1977 was not a friendly one. Although he had created tremendous excitement at Harvard, his ideas proved too threatening to the establishment.[2] The critics carped and attacked Fell's "method," although the main argument against him seems to be that his ideas went against the accepted views.

But the genie was out of the bottle. Fell founded the Polynesian Epigraphic Society in 1973. This later became the Epigraphic Society, which published Fell's papers and those of other epigraphers, geographers, archeologists, and interested amateurs[3] From all over the world, interested individuals sent Fell inscriptions and information.

Fell's work on Maori, and the spectacular translations from the Caves of the Navigators, never received the prominence given to his work on America, and the Epigraphic Society Occasional Publications are, to my knowledge, the sole source for the astounding story that follows.

The Eratosthenes Expedition

As word spread of Fell's work on the Egyptian roots of Maori, epigraphers and others sent him copies of inscriptions. The inscriptions in the Caves of the Navigators at Sosorra in McCluer Bay, Irian Jaya, for example, were sent to Fell by Ruth K. Hanner of Hawaii, who noticed that they had Egyptian features. These cave inscriptions were discovered in 1937-1938 by an expedition led by Josef Röder from the Frobenius Institute at the University of Frankfurt, Germany. Röder's group was investigating the religious practices of the native inhabitants, and took photographs of the inscriptions and drawings, but could not decipher them.[4]

The Sosorra works included drawings, paintings, astronomical and navigational diagrams and calculations, many in colored chalk and most in charcoal, and all preserved by a thin stalactite layer. Among the diagrams were those of ships and fishing gear, astronomical observations, "with illustrations of celestial phenomena and astronomical apparatus, including the

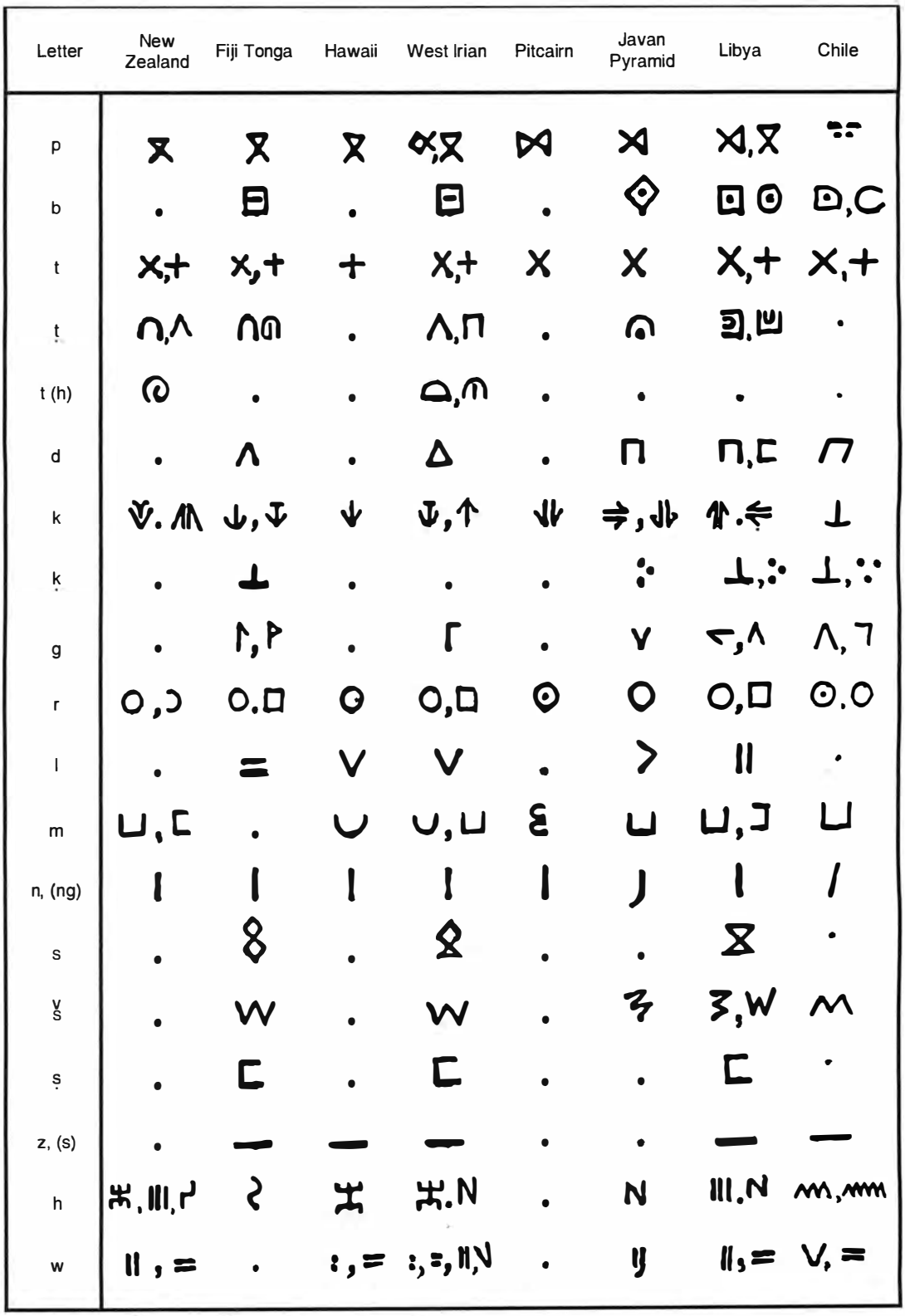


Figure 3
MAORI ALPHABETS OF LIBYA, POLYNESIA, AND CHILE

This chart, compiled by Barry Fell, compares the alphabets he compiled from various inscriptions.

Source: Reprinted with permission from the Epigraphic Society Occasional Publications, Vol. 2, No. 21. See Note 3.

cross-staff, a variable-angle sundial for use in various latitudes, a computing instrument for correcting zenith angles to latitude, dividers, set-square, charts of the sky showing particular constellations," and numerous religious drawings and paintings of Graeco-Egyptian deities. There are also some records of mining gold and silver.

Fell determined that the most important inscription was what he interpreted as a concise proof, in words and drawings, of the Eratosthenes experiment at Syene and Alexandria to demonstrate that the world was round![5] (The astronomer Eratosthenes was the head of the great library at Alexandria, and the most important scientist of his time.) The author was Maui, who identified himself as an astronomer and navigator of a flotilla of six ships, captained by Rata, that had set out from Egypt around 232 B.C., during the reign of Ptolemy III, on a mission to circumnavigate the globe.

The dating of the occupation of these Caves of the Navigators is set as 235-225 B.C., based on Maui's record of a solar eclipse, and a comet, occurring in the 15th year of the reign of Pharaoh, which would coincide with the annular eclipse of Nov. 19, 232 B.C. The elegant proof of Eratosthenes' theorem is introduced by Maui as follows: "This particular theorem Eratosthenes, an astronomer of the delta country in Lower Egypt, disclosed to Maui."

Fell's supposition was that the expedition was sent out by Ptolemy III both to find new sources of gold for coins and to demonstrate Eratosthenes' "newly propounded doctrine." Based on Fell's preliminary translations, made in 1974, Fell and others working with him concluded that the voyage of the flotilla, led by Rata and Maui, had been planned by Eratosthenes, and would follow a great circle route around the globe. Therefore, they forecast that inscriptions could be found on the west coast of the Americas, dated a year or so later—231 or 230 B.C. The Pacific currents would have taken the flotilla from New Guinea to, approximately, the region from Baja California to Panama, and it was thought that the ships would then go both north and south to find a seaway through the land mass.

Learning of Fell's Nov. 13, 1974, seminar, geographer George F. Carter, Sr., a professor at Texas A&M University with an interest in ancient inscriptions (and who has made independent discoveries of paleolithic settlements in the Americas) recalled a cave inscription that he had copied from a German-language scientific journal published in Chile, which he found at the Johns Hopkins University Library in Baltimore, in the 1950s, when he was teaching in the geography department there. The inscription was copied in 1885 by Karl Stolp, who had taken shelter in a cave near Santiago during a storm (see accompanying article).

Carter thought the script was similar to the Polynesian inscriptions. He was right: As Fell was able to translate it, the Santiago inscription gave the date as the "regnal year 16," which would have been 231 B.C., and also had Maui's name:

"Southern limit of the coast reached by Maui. This region is the southern limit of the mountainous land the commander claims, by written proclamation, in this land exulting. To this southern limit he steered the flotilla of ships. This land the navigator claims for the King of Egypt, for his Queen, and for their noble son, running a course of 4,000 miles[7], steep, mighty, mountainous, on high uplifted. August, day 5, regnal year 16."

The flotilla never returned to Egypt. It is assumed that when the Egyptians did not find a navigable passageway through America, they turned back to return the way they had come, across the Pacific. One ship, according to an inscription, was apparently wrecked on Pitcairn Island.

Fell proposes that Rata, Maui, and the other 300 or so members of the expedition became the founding fathers of Polynesia. In fact, he says, the actual names Rata and Maui appear in Polynesian legend. Further, he says, the ancient Maori-Libyan language, writing, and knowledge became the "initial heritage of Polynesia." Libyan inscriptions, according to Fell, were found in New Zealand "as late as 1450 A.D."

The Importance of Rata and Maui

The Egyptians' knowledge of navigation and their ability to make long-distance voyages, has been dated as far back as 2890 B.C., exploring the African Coast, the Red Sea, the Indian Ocean, and even so far as the southern polar circle.[6] These voyages to find and mine gold, and also to colonize, involved thousands of Egyptians, and very large ships (67 meters long, according to one replica found in an Egyptian tomb). Thus, by 232 B.C., Rata and Maui should have had some knowledge, at least, of previous long-distance voyages.

They also knew from Eratosthenes that the circumference of the Earth was 250,000 stades (approximately 28,000 miles), and they had state-of-the-art astronomical and navigational equipment.[8]

The fact of a 3rd century B.C. voyage across the Pacific, then, is entirely possible. What boggles the mind, however, as pointed out by physical economist Lyndon LaRouche, in a speech at a Schiller Institute conference in Germany in November, is the fact that another science-directed transoceanic voyage to the Americas did not take place until Columbus's 1492 voyage—1,723 years later. In other words, there was no civilization capable of making that kind of expedition, between 232 B.C. and 1492.

More articles on this and related topics are planned for future issues.

Notes

1. A short biography and bibliography of Fell, who died in 1994, can be found on the web page of the Royal Society of New Zealand: http://www.rsnz.govt.nz/home.html.
2. The voyage of Maui and Rata was brought to our attention in October 1998 by John Chappell, director of the Natural Philosophy Alliance, who attended some of Fell's talks at Harvard in 1975.
3. For more information, contact the Epigraphic Society, Donal B. Buchanan, Secretary, 8216 Labbe Lane, Vienna, Virginia 22182-5244 or e-mail donalb@aol.com.
4. The inscriptions appear in J. Röder's *Felsbilder u. vorgeschichte d. McCluer-Golfes West-Neuguinea Ergebnisse d. Frobenius-Expedition 1937-1938, published by the Frobenius Institute in 1959 (Frankfurt).*
5. An illustration of the Eratosthenes proof can be found on page 51 of this issue. Articles on Eratosthenes, the inscriptions from the Caves of the Navigators, and the importance of the voyage appear in *Executive Intelligence Review*, Nov. 20, 1998.
6. Dr. George F. Carter reviews the documentation, especially the 1952 work of Heinrich Quiring, in "Egyptian Gold Seekers and Exploration in the Pacific," The Epigraphic Society Occasional Publications, Vol. 2, No. 27, Feb. 1975.
7. There is a descrepancy between Fell's rendering and the Stolp Copy. In the fifth text line, where Fell shows 4 number marks, compared to the 6 number marks found at the end of the 5th line in the Stolp copy (See p. 66). If it is 6,000 miles, it would have allowed the flotilla to travel northward about 1,000 miles, before turning south, down the coast of South America, in search of an eastward passage.
8. A future article in *21st Century* will examine the astronomical devices recorded by Maui, and his writings on the constellations in the southern sky.

Indian Inscriptions from the Cordilleras in Chile

Found by Karl Stolp

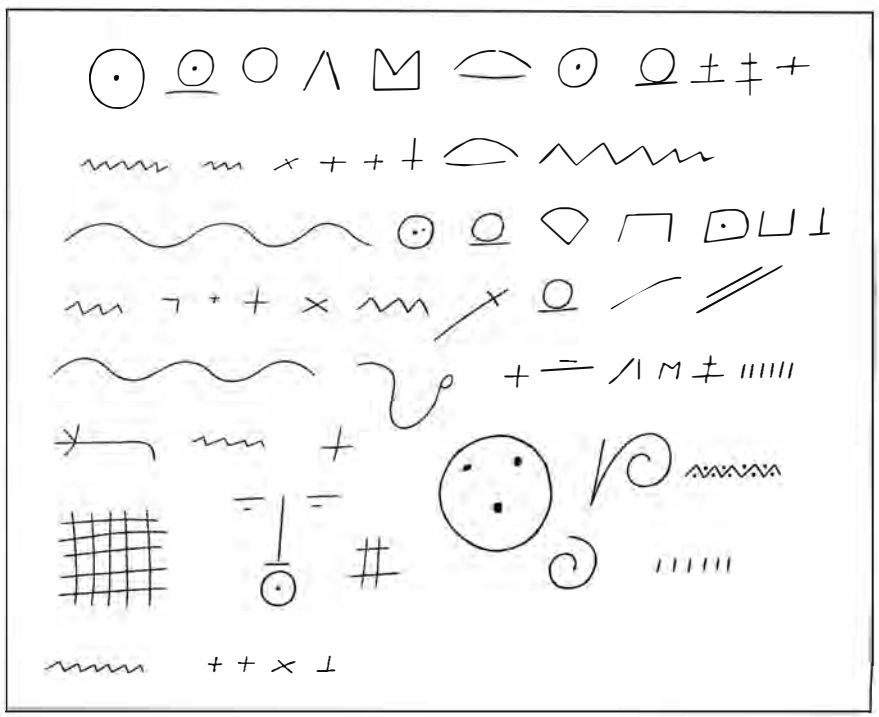
EDITOR'S NOTE

This is an account by German-Chilean engineer Karl Stolp of how he found the cave inscription in Chile in 1885, which was deciphered by Barry Fell, nearly a century later. Stolp's story, which he presented to the German Scientific Association in Santiago, Chile, on Aug. 22, 1888, appears in the German-language journal, Verhandlungen des Deutschen-wissenschaftlichen Vereins zu Santiago de Chile, *Vol. 2, 1889-1893, pp. 35-37, published in Valparaiso.*

Geographer George F. Carter came across the inscription at the Johns Hopkins University Library in the 1950s, and sent it to Fell in the early 1970s, after learning of Fell's work with similar inscriptions.

The German text was provided by the Special Collections section of the Milton S. Eisenhower Library, Johns Hopkins University, and was translated by Geoffrey Steinherz.

* * *



SANTIAGO CAVE INSCRIPTION COPIED IN 1885 BY KARL STOLP

As I was crossing the Cajon mountain range in 1885, I was forced by a sudden snowstorm to seek shelter between the cliffs of a ravine. Leaving our horses behind in the valley, I looked for refuge with my people in a cave at the southern slope of the ravine. Located at 2,000 feet above the valley, the cave is very difficult to reach and is therefore seldom visited by the natives, and especially avoided by them because secret signs and spirits were said to be present there. That was maintained by the shepherds who lived in the vicinity.

The adverse weather, however, forced me in spite of the bad location, signs, and spirits to seek it out. As I have said, it was very inaccessible, with steep cliffs disappearing beneath it and sheer cliffs rising above. The cave stayed completely dry in all weather, as the deep dust indicated. Unusual signs which immediately aroused the curiosity of a visitor were displayed on several smooth cave walls. But, not only on the walls, but also on the face of the cliff above, there were many signs to be seen.

It is incomprehensible how the signs outside the cave could have been painted, because they were located at a place where even with a ladder one could not reach them, because they were above a cliff, and from above they were even more inaccessible. The only possibillty was that at that time, beneath the painted cliffs, there were other cliffs from which one could have painted the signs, which had since then broken off and plunged into the ravine.

As has been mentioned, the cave was filled with dry dust, which on the average was 1 foot deep. I had the cave examined more closely and removed the dust, and found at the bottom seven human skeletons. Five of the skulls appeared to be men, and two women. I gave the best specimen to Dr. Phillips for the local national museum. Some of the skeletons were so brittle, they fell apart in my hands.

The facial angle of the skulls was, on the average, 75 percent and the thickness of the roof of the skull, forehead, and parietal bone was 1 centimeter. Next to the skeletons were crudely woven fabrics of bast, not wool, and some shell jewelry.

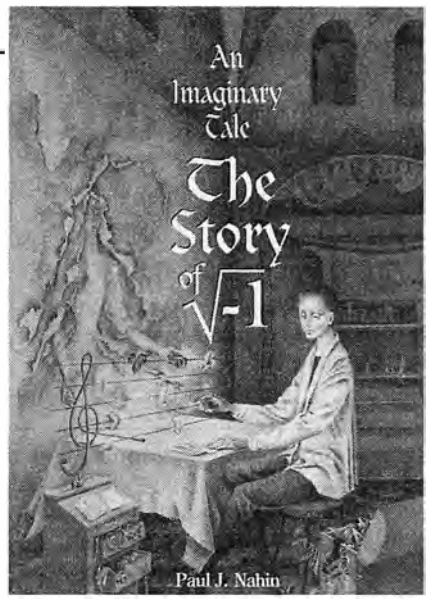
The unusual signs which covered the stones and walls of the cave were executed in red, black, and white colors. The chemical analysis revealed that the red, as well as the black color, was composed of red, iron-rich clay, and the white was made of kaolin or ash.

The question arose, "Are these signs of Indian origin or not? At first glance one would think that the signs came from the land of the pyramids, and someone had amused himself by decorating the walls of the cave with them. But for what? And, on top of that, [why] in such inac-

Continued on page 71

A Formalist Look at a Fascinating Paradox

by Bruce Director



An Imaginary Tale: The Story of $\sqrt{-1}$
Paul Nahin
Princeton: Princeton University Press, 1998
Hardcover, 257 pages, $24.95

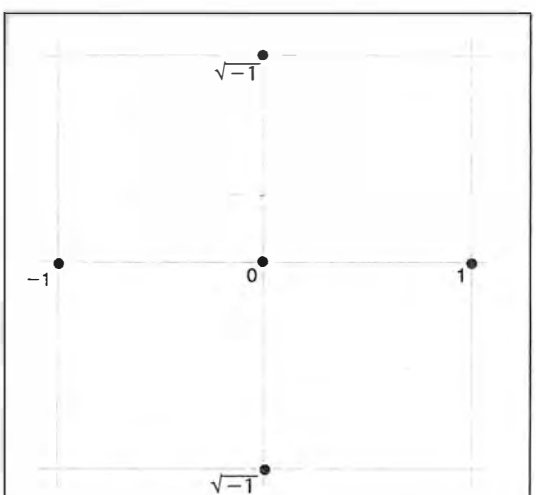
The paradoxes associated with the concept of the square root of −1 have spurred some of the greatest minds in history to investigate the underlying hypothesis of space. Unfortunately, Prof. Paul Nahin has missed that entirely. As an electrical engineer with a background in popular science and science fiction, Nahin is perhaps blinded to these more fundamental investigations. Consequently, his book presents this important and fascinating subject, from the standpoint of generally accepted formalist dogmas.

To be fair, a discussion of the deeper meaning of $\sqrt{-1}$ is not easy. Carl Friedrich Gauss, who more than anyone else developed the concept, wrote to his friend Hansen on Dec. 11, 1825:

"These investigations lead deeply into many others, I would even say, into the Metaphysics of the theory of space, and only with great difficulty can I tear myself away from the results that spring from it, as, for example, the true metaphysics of negative and complex numbers. The true sense of the square root of −1 stands before my mind [Seele] fully alive, but it becomes very difficult to put it in words; I am always only able to give a vague image that floats in the air."

To communicate this "vague picture" as Gauss describes it, scientists must be prepared to abandon mathematical formalism, and accept what economist Lyndon LaRouche has long put forward: that "Poetry must supersede mathematics in science."

In fact, the square root of −1 and Gauss's notion of the complex domain, is precisely that sort of metaphor that LaRouche has insisted upon. Most important, Gauss saw in his conception of complex numbers, a direct refutation of Kant and Euler, whose wrong-headed insistence that the nature of space can be determined from formal mathematics, continues to hamper scientific progress to this day.



DEMYSTIFYING IMAGINARY NUMBERS
To make the so-called imaginary numbers real, Carl Gauss suggests that the reader draw a grid and construct a spatial depiction of the imaginary numbers. He shows that $\sqrt{-1}$ is the mean proportional between +1 and $\sqrt{-1}$. A mean proportional is a value x between two numbers a and b such that a *is to x as x is to b. This can be expressed algebraically as $x = \sqrt{ab}$. Gauss would have named the numbers direct, inverse, and lateral.*

Unfortunate Formalism

Professor Nahin is an unfortunate example of this problem. Attracted to the paradoxical nature of $\sqrt{-1}$, he nevertheless avoids the metaphysical questions, relying on the formalism of Euler and Cauchy. He presents the significance of $\sqrt{-1}$ in terms of the applicability to physical problems of certain mathematical functions, and the algebraic uses of this quantity, instead of its more profound implications. Consequently, the real application of complex magnitudes is never presented to the reader.

Perhaps the most eloquent discussion of this subject comes from Gauss himself, in his second treatise on biquadratic residues, which receives no mention in Nahin's book. There, Gauss states: "The difficulty, one has believed, that surrounds the theory of imaginary magnitudes, is based in large part on that not so appropriate designation (it has even had the discordant name impossible magnitude imposed on it). Had one started from the idea to present a manifold of two dimensions (which presents the conception of space with greater clarity), the positive magnitudes would have been called direct, the negative inverse, and the imaginary lateral, so there would be simplicity instead of confusion, clarity instead of darkness."

This book only contributes to the confusion, when clarity is so dearly needed.

A Vivid, but Narrow View of a War-winning Technology

by J. C. Smith, Jr.

Monitor: The Story of the Legendary Civil War Ironclad and the Man Whose Invention Changed the Course of History
James Tertius deKay
New York: Walker and Company, 1997
Hardcover, 247 pages, $21.00

This book provides a gripping, exciting account of the epic Civil War battle between the Confederate *Virginia* (formerly the *Merrimac*) and the Union *Monitor,* in Hampton Roads, Virginia, in March 1862. So vivid is the writing, that I finished the book with mental images as clear as if it had been a television mini-series.

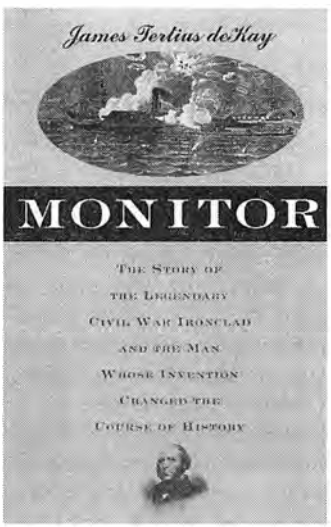
And that's the problem with the book. As the author states, "[T]his retelling of the *Monitor*'s story is designed as popular history. . . ." But there are many things about the creation of the two ironclads and the broader circumstances of the battle that the author could have striven to make popular knowledge, instead of simply writing another "best seller."

Above all, the creation of the ironclad *Monitor,* and the development of *Monitor*'s designer, John Ericsson, were a vital part of a broader project not only to save the Union, but to destroy, once and for all, the power of the British Empire, then making its third attempt to destroy the Union, by backing the Confederacy. There is none of this larger picture, however, in the deKay book.

The Battle

The battle between the two ironclads, occurred on March 9, 1862. *Virginia* had entered Hampton Roads one and a half days before *Monitor.* Within two hours of its arrival, *Virginia* attacked, rammed, and sank, the steam frigate *Cumberland,* whose armament included 22 80-pound cannons. One hundred and twenty-two men were killed. One hour later, *Virginia* destroyed the *Congress,* virtually shredding her with rifled cannon fire, and killing 136 of the crew of 434, including the captain. Nightfall stopped the destruction of the steam frigate *Minnesota.*

In that one day, *CSS Virginia* had begun to break the Union blockade, reversing the strategic balance between North and South.



Members of Lincoln's Cabinet panicked. Some calmed down a little when informed that the 24-foot draft of the CSS *Virginia* would prevent it from reaching Washington, D.C. *Monitor* arrived in Hampton Roads on March 8, 1862, and its commanding officer prepared to defend the *Minnesota* the next morning.

Virginia and *Monitor* fought a ferocious battle for more than three hours, sometimes at point-blank range. *Virginia* had run aground once during the battle, and likely would have had her armor pierced by *Monitor's,* guns, had she been using full gunpowder charges in her guns, instead of the half-charge stipulated by the Navy. (This decision occurred because during testing, a gun had burst, which was falsely blamed on Ericsson.)

For different reasons, both ships sheared off, and never engaged each other again. *Monitor* had re-closed the Union blockade.

Ericsson's Ironclad

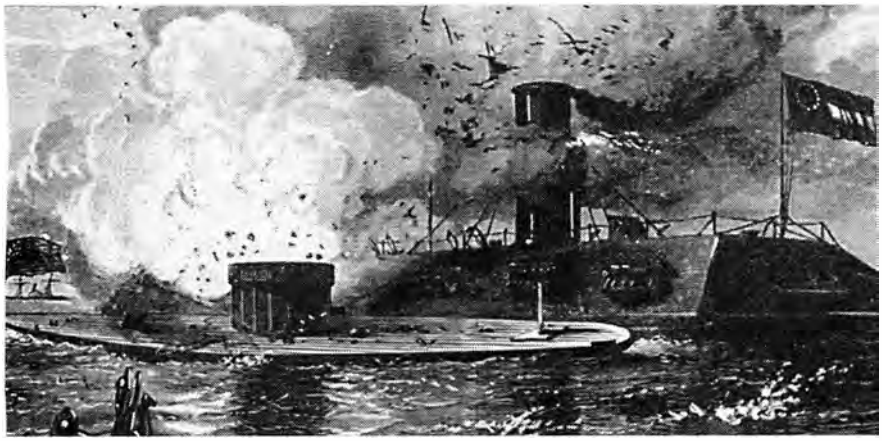
The *USS Monitor* had been designed and built, from the keel up, as an ironclad warship. Her designer was the inventor and engineer Capt. John Ericsson, born in Sweden in 1803. In 1837, Ericsson had tried to sell the British Admiralty a steamship that was powered by his invention, the propeller, and could exceed 10 knots, a record at that time. The Admiralty rejected his design, calling it ". . . useless in practice because, the power being applied at the stern, it would be absolutely impossible to make the vessel steer."

This, and the rejection of his other designs for an advanced steam locomotive and other inventions, finally convinced Ericsson to venture to America, where he was recruited by the U.S. Navy to build his design for a "sub-aquatic system of naval warfare." The ultimate design consisted of a hull, constructed of oaken beams and covered with iron plate, and an iron-cladded deck. Her hull was modestly sized, 124 feet long, with a draught of 6-1/2 feet. The deck was 172 feet long, and 41 feet wide, enough to protect the propeller and the sides of the hull.

In the center of the deck, Ericsson designed a revolving turret, mounting two 12-inch Dahlgren guns, which was 20 feet in diameter, 9 feet high, and built of 9 layers of 1-inch iron plate and armor. Its propeller would move her at 6 knots. It was begun on Oct. 25, 1861, and delivered to the Navy on March 3, 1862, a little more than 120 days after the laying of her keel.

The Rebuilt *Merrimac*

The CSS *Virginia* had been built by placing an armored deck and citadel, with openings for naval guns, upon the hull of the captured USS *Merrimac,* a steam frigate salvaged by the Confederates after Union naval forces had unsuccessfully prevented its capture, and had attempted to burn it. The Confederate Secretary of the Navy, Benjamin Mallory, had been Chairman of the Naval Affairs Committee while still a U.S. Senator, and was quite familiar with the work of the French and British to begin developing such ironclads. He repeatedly demanded, and finally succeeded in obtaining, orders to build the first Confederate ironclad, which he intended to use to lay waste Union shipping and ports.



www.arttoday.com

A 19th century engraving of the battle between Monitor *and* Merrimac.

Reconstruction of *Virginia* began on July 12, 1861. The iron for her cladding was difficult for the Confederates to produce, and consisted largely of recycled railroad rails. The only mill that could produce armor plate, in Richmond, had to modify its rollers to make the necessary 2-inch armor plate.

Her guns consisted of some of the 54 new Dahlgren guns (captured at Norfolk), the highest technology naval guns available anywhere. Design and construction difficulties prevented her launch and engagement until March 8, 1861. *Virginia* could only turn its guns by changing the head of the ship. *Monitor*'s turret, in contrast, allowed aiming and concentrating the fire of 2 Dahlgren guns. *Monitor*'s machinery and living spaces were all below the waterline; hence, Ericsson's term, a "sub-aquatic system of naval warfare."

What's Missing

Now, for what's missing from deKay's account:

It would be of interest to know, for example, who taught young Ericsson, while his father was an engineer on the Swedish Göta Canal. At the time, Lazare Carnot had just revolutionized warfare in France, and had created the Ecole Polytechnique to train scientists and engineers. Were any of Ericsson's teachers from the Ecole? What method of thinking did they introduce to Ericsson?

The work of Carnot, and of Carl Friedrich Gauss, was the basis for Alexander Dallas Bache's project, to establish the U.S. Naval Academy. Bache's idea was to create a cadre of American scientific naval officers, to both develop the Union and to export the American Revolution to Europe—by making it possible to defeat the British Navy.

Bache, a grandson of Benjamin Franklin, was an engineer and West Point graduate, who organized a series of projects during the 1830s and 1840s, designed to make the United States the hegemonic global power, capable of defeating the British. One of his projects was to re-create, at the Girard School for Orphans in Philadelphia, Carl Friedrich Gauss's experiment to measure the Earth's magnetic field.

Two other men directly involved in the Girard project were Charles H. Davis, and Commodore Biddle, both members of the Naval Board that ultimately approved Ericsson's *Monitor* design.

Just this brief look at the republican network that shaped early U.S. naval history makes it clear why it is important to know something about Ericsson's education.

Ocean-going Monitors

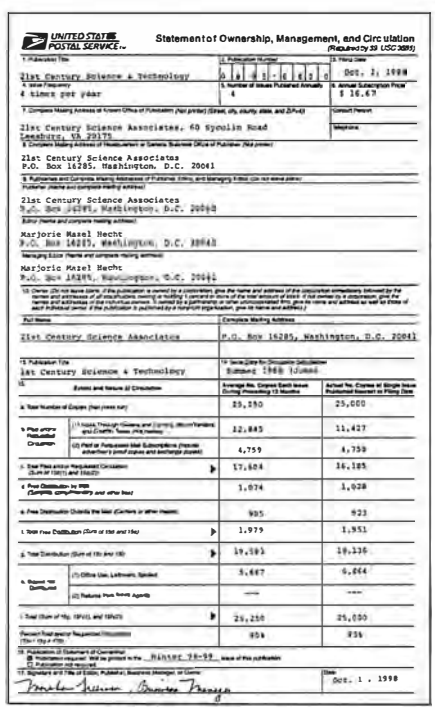
On another matter, the author could have helped the reader, by exploring a little the development, and planned deployment, of follow-on designs for ocean-going monitors. Did Lincoln intend to blockade the British after the Civil War, and punish them for their role in attempting to permanently destroy the Union? Ocean-going monitors would have proven the perfect platform for such an operation.

After the report of the battle between the *Monitor* and the *Virginia,* the British Admiralty cancelled all wooden warship requisitions, and began to build armored monitors as fast as its limited industrial capacity could build them. America had, by the end of the Civil War, a vast industrial capacity. The nation had begun to build a fleet of ocean-going monitors, adequate—were they to have been so deployed—to engage the British fleet. If Lincoln had had such a plan, it could have succeeded.

What actually happened to U.S. strategic planning after the Civil War? Immediately after Lincoln's death, in 1865, the Navy's tonnage stood at more than 500,000 pounds: 700 ships, 5,000 guns, and 59,000 officers and men. By 1870, tonnage had been reduced to 200 ships, 200,000 pounds, and 1,300 guns, including 500 obsolete cannon. By 1880, the Navy's tonnage had been reduced further, from 200,000 tons in 1870, to 147,000.

In 1880, the U.S. Navy spent $500,000 to rebuild a wooden warship, *Omega,* while Britain had 37 iron battleships. In the 1880s, Secretary of the Navy Tracy ordered the building of armored cruisers, utilizing a breakthrough technology in armor plating, but the U.S. Navy did not become powerful enough to defeat an Empire until World War II, almost 60 years later.

Perhaps all this is not within the scope of deKay's little book. But the public would have been well served at least to have been able to catch a glimmer of the scope of the republican project. The full story of the *Monitor,* and deKay's engaging writing style, could have helped provide that insight.



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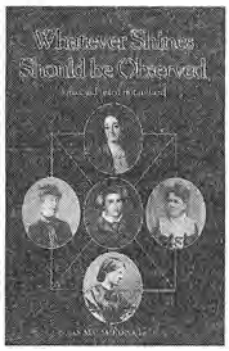
Irish Women's Contributions to Science

by Marsha Freeman

Whatever Shines Should Be Observed
Susan M.P. McKenna-Lawlor
Dublin: Samton Limited, 1998
Hardcover, 136 pages, $17.00



This wonderful book, whose title is taken from the motto of the 19th century astronomer William Herschel (*quicquid nited notandum*), is about the contributions of five women during the last century. It was written by an Irish woman who herself has made substantial contributions to science, Susan M.P. McKenna-Lawlor. Four of the women in the book were Irish, and the fifth married into an Irish family.

The women McKenna-Lawlor describes plowed new ground by intruding into the man's world of the physical sciences at a time when girls were not even afforded an education in such subjects. One, Agnes Mary Clerke (1842-1907), became only the third woman to have had bestowed upon her honorary membership in the Royal Astronomical Society. Their interests ranged from the microscopic to the astronomical, and in the particular example of Mary Ward (1827-1869), her accomplishments lay in both fields.

Microscopic to Astronomical

From the time she was a child, Mary Ward used a magnifying glass to discover the secrets of the insect world, and in 1857, she published a lighthearted book with her sister titled, *Entomology in Sport, Entomology in Earnest,* in order to catch "unwary youth" in the "meshes of science while seeking only amusement."

In 1864, in her book *Microscope Teachings,* Ward undertook not only to share what she had observed under the microscope, but to instruct the reader in everything from how to buy a microscope and which kind is best suited to each purpose, to how to best illuminate various specimens, and even how to observe live tadpoles.

Ward's detailed and meticulous drawings of what she had observed about the structure and organization of life are intended to prepare the novice for the wonderful world he or she was about to discover with the use of a microscope.

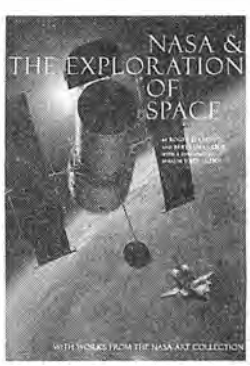
Before the age of 10, Ward was also looking toward the heavens, making observations in 1835 of Halley's Comet, which, the author states, "filled her with wonder." In 1859, Ward published a companion, of sorts, to her book on microscopes, titled *Telescope Teachings.* In this volume she covers the essentials of the telescope, and such subjects as how to view sunspots, accompanied with drawings from her own observations. She also reproduces a stunning series of observations she made of Donati's comet in 1858 in her drawings and diary.

The other women whose stories are told in this book are Mary, Countess of Rosse (1813-1885), who made contributions to photography; Ellen Mary Clerke (1840-1906), a poet and writer on literary and scientific subjects; and Margaret Huggins (1848-1915), who, with her husband, William Huggins, made major contributions to astrophysics.

It is not surprising that Susan McKenna- Lawlor would be the author of such an unusual book, or have such an interest and affection for the women whose lives and accomplishments she chronicles. She is currently a professor in the Department of Experimental Physics at the National University of Ireland, and founder of Space Technology Company, Ltd. She participated in the American Skylab and Solar Maximum Mission programs, was the Principal Investigator for the first Irish experiment flown by the European Space Agency, and she is flying and preparing experiments for scientific satellites.

Resting on her combination of contributions to solar and planetary science, and work in the history of science, Susan M.P. McKenny-Lawlor has made her book as delightful as the women she is describing.

The Art of Exploration



NASA & the Exploration of Space
Roger Launius and Bertram Ulrich
New York: Stewart, Tabori & Chang, 1998
Hardcover, 224 pages, $60.00

Many histories of NASA have been published over the years, but this work, produced to celebrate the 40th anniversary of the space agency in October, is the first that is dedicated to the fruits of the 30-year NASA Art Program.

Although there is great beauty and drama in depicting the hardware of space exploration, especially launches of the magnificent Space Shuttle, and the enormous Saturn V rocket that took men to the Moon, what I found most engaging in the paintings and drawings in this book, were those that portrayed the people of space exploration.

Over the decades of space activities, there have probably been thousands of photographs taken of astronauts, mission control personnel, and other NASA employees. But most photographs can capture only one moment in a life, while a painting can crystallize the entire history and personality of a subject. There are several such paintings presented in this work that provide an insight into who these people are, that have taken mankind into space.

In his introduction to the book, former Senator and recent astronaut John Glenn states that "our legacy will be marked by not only the many tangible benefits of the space program, but by our ability to instill that questing nature of the American spirit in generations to come."

This book makes an important contribution to that legacy.

—Marsha Freeman

Indian Inscriptions from The Cordilleras in Chile

Continued from page 66

cessible places? Why would the artist want to paint his signs on such neck-breaking places, which one could only reach today with special scaffolding? The place is so inaccessible that I could not find a place to position my camera. The signs could only have been painted from a position on firm ground. There must have been firm ground in front of the cliff face when the signs were made, and this firm ground must have later plunged into the abyss many hundreds of years ago, because growing in the ravine were many massive cypresses and soap trees (*Quillaja saponaria)* of advanced age, which had been clearly damaged or destroyed by landslides.

The skeletons along with the shell jewelry and weaving allowed one to assume that the skeletons were very old, at least hundreds of years old. From their construction, the skulls could only have belonged to very intelligent race of men, probably the forefathers of our Araucaner (Chile and west Argentina). The skulls and many other bones showed signs of healed wounds. From their appearance, the signs were made with fingers from color or minerals that came from another location, and used here.

In my opinion, in view of the location and the conditions in which I found these signs, these signs were of Indian origin, although their unusual form called to mind the old Egyptians rather than the Araucaner.

The cave itself was called by the people "la casa pintada," or painted house.

Yet other signs, which do not resemble these described, are to be found on a stone in the vicinity of Antofogasta. These drawings appear at first glance to be of Indian origin, as the successfully executed photographs of Mr. F. San Roman, director of the local geographical and geological section, indicate. Judging from the Huanaco drawings, it can be determined that in former times, when the large drawings were made, the stone stood upright, and that later on, the ground beneath it was eroded and it tipped over, at which point many draftsmen in later periods continued decorating it with drawings.

International Station Opens New Era In Space Exploration

by Marsha Freeman

The successful launch on Nov. 20 of the Russian-built Zarya ("Sunrise") spacecraft opened the era of permanent manned presence in space. The four-year process of assembling the International Space Station began a few days later, with the Dec. 4 launch of the Space Shuttle Endeavour, which delivered the second station element, called Unity.

When completed in 2004, the International Space Station (ISS), will be larger than a football field, and will weigh more than 1 million pounds. The ISS will be made up of more than 100 parts, delivered to Earth orbit via more than 45 launches, and connected together during more than 850 hours of spacewalks by astronauts.

ISS will provide world-class laboratory facilities for scientists and engineers working in many disciplines, from many nations in the world. The development and fabrication of the hardware itself is already pushing forward the state-of-the-art in materials, robotics, energy production, and other technologies.

On board the station, research will be conducted to examine the effects of microgravity on living systems; to develop new materials; to take advantage of the weightless environment in the study of many phenomena such as crystal growth, combustion, tissue growth; and to lay the basis for life in space and on other planets, such as the Moon and Mars.

It is as impossible to produce a list of accomplishments expected from research aboard the International Space Station, as it would be to determine what breakthroughs in science will be forthcoming when a new research laboratory is opened in any city on Earth. But we do know that this unique environment can be used to conduct research to help us live better on Earth, and to learn how to live and work in space, as a prerequisite to going further out into the Solar System.

A Dream of Mankind

From the earliest days of space experimentation, the expectation existed that man would learn how to live in space. In the 1920s, space pioneer Hermann Oberth, who grew up in a town in Romania where the only connection to the outside world was a railroad, described the construction of a "station" in orbit, and the many uses for such a future facility. Until 1971, cosmonauts and astronauts could ride a rocket into orbit, or to the Moon, but they did not have a "home" in space. In that year, the Soviet Union launched its first Salyut space station, which was a very small, temporary facility; the Soviets followed Salyut with six more stations through the mid-1980s.

In 1986, the Soviets launched the core of the new, modular Mir space station, which eventually became the anchor for five laboratories in Earth orbit. For nearly 12 years in orbit, far beyond its rated 5-year lifetime, Mir has done a yeoman's job as a platform for research and international cooperation. ISS will replace Mir with a facility four times as large, incorporating technology of the 1990s, and the benefit of participation by the only other spacefaring nation, and more than a dozen other nations, so far.

The International Space Station potentially opens the door to virtually every nation in the world, to participation in this great project. In the 21st century, every nation should become spacefaring, and the International Space Station provides the first step for many.

The core participants in ISS have been the United States, the European Space Agency nations, Japan, Canada, and Russia. In October 1997, NASA announced that Brazil would be joining the project, as a bilateral partner with the United States. Under this arrangement, the Brazilian Space Agency will provide flight equipment and science payloads for American facilities on the station. In exchange, Brazil will have access to the station's research facilities, and a flight opportunity for a Brazilian astronaut during the course of the program.

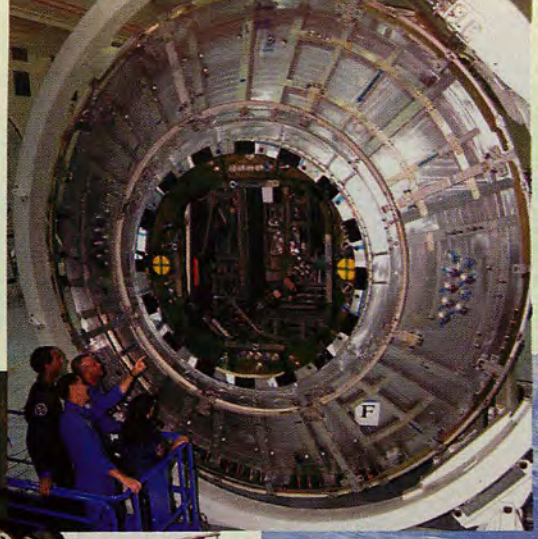
The government of Ukraine announced Nov. 25, that it would be joining the project, concluding an agreement with the Russian government. The Ukrainian Space Agency will construct a scientific module to replace one of two laboratories the Russians were to build for ISS, but for which they do not yet have the funds. The plan is to complete the $150 million module by the year 2003 or 2004.

A New Dawn

The Zarya, or "Sunrise" spacecraft that the Russians launched on Nov. 20 will function as a control and propulsion module while the first elements of the station are being assembled. It is more than 41 feet long and weighs 44,088 pounds. Zarya's solar arrays can produce an average of 3 kilowatts of electricity. Although it is rated for an operational lifetime in orbit of 15 years, many of its functions will be superseded by future Russian station modules.

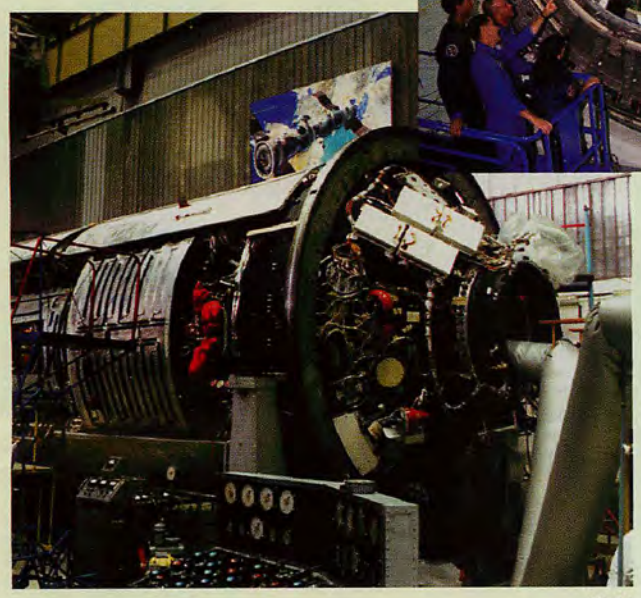
The module is designed to perform automated rendezvous and docking maneuvers. When the third Russian element, the Service Module, is launched this summer, it will be on an unmanned Proton rocket, and the two Russian elements will dock without any assistance from cosmonauts.

Zarya's docking ports can accommodate Russian Soyuz vehicles carrying crew members to the station, as well as unmanned Progress supply ships, like those used to service the Mir. The module has 16 fuel tanks that can hold more than six tons of propellant. To keep itself and the early station assembly in the



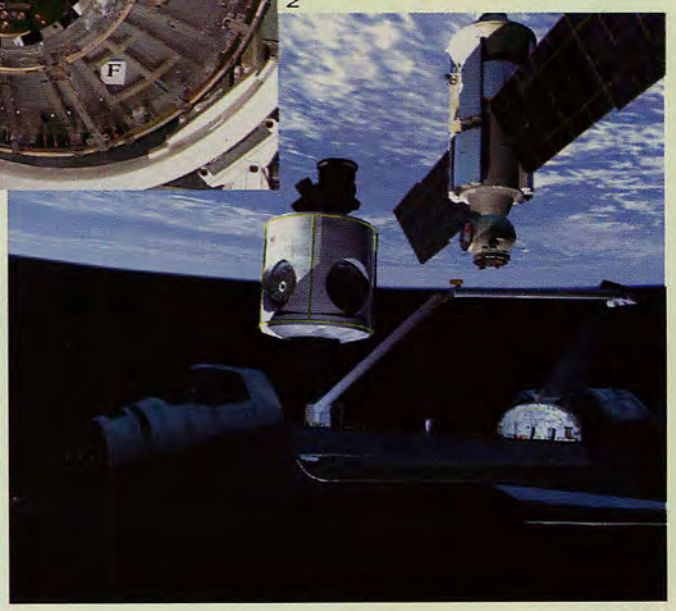
The American Unity station module being inspected at the Kennedy Space Center in July 1997, by the Space Shuttle crew that would later carry it to space. Shown is one of the six docking hatches.

NASA



NASA

The first Russian element for the station was known as the Functional Cargo Block before it was renamed Zarya at launch. Here it is seen in final assembly at the Khrunichev State Research and Production Space Center in Moscow.



NASA

In this artist's drawing, the Space Shuttle Endeavour prepares to capture the Russian Zarya with its robot arm (upper right), in order to mate the first two elements of the International Space Station.

proper attitude in orbit, Zarya has 24 large steering jets and 12 smaller ones.

There are also two large engines available to reboost the assembly and make orbital changes. Although there is no "atmosphere" in orbit, atomic oxygen at an altitude of 240 miles does produce drag on the station, which will need to be periodically reboosted to the proper altitude.

Making the First Connection

The Unity station element, launched into space aboard the Space Shuttle Endeavour on Dec. 4, is a six-sided node with docking ports, that will connect the U.S. station modules to arrive in the future. Unity is 15 feet in diameter and 18 feet long, weighing in at 25,600 pounds. The node will also function as a passageway between modules for crew members and for essential resources such as electrical power, fluids, environmental and life support systems, and data systems to supply the living and working areas of the station.

To perform that function, Unity contains more than 50,000 mechanical pieces of equipment, 216 lines to carry fluids, and 212 internal and external electrical cables. At each end of the node is a pressurized mating adapter, or PMA, which allows the Space Shuttle or Russian elements to be attached to Unity.

Not everything will be able to be attached through Unity's docking ports. Two additional connecting nodes, now being manufactured by Alenia Aerospazio in Italy, will be supplied by the European Space Agency to NASA.

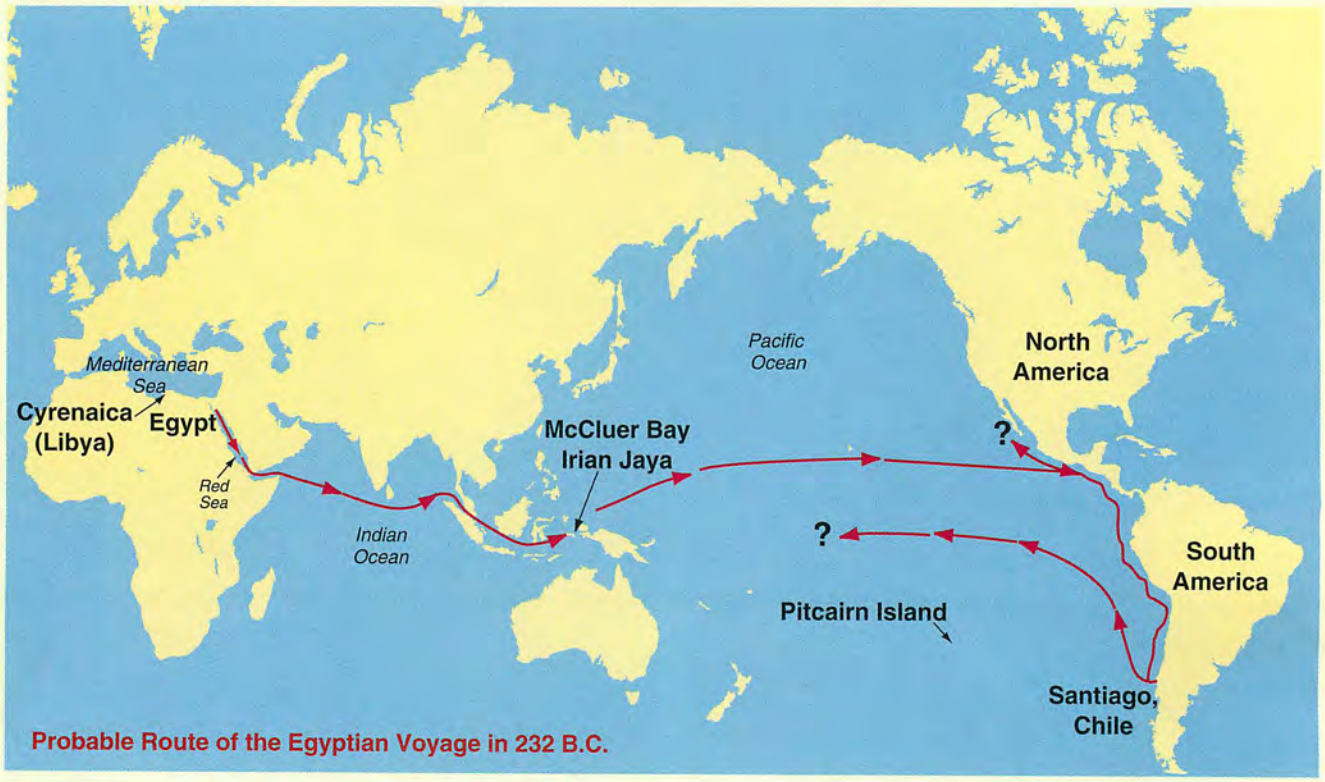
Over the next four years, the International Space Station will grow in complexity and capability with every mission. In early 2000, the first crew—Russian and American—will take up residence in their new home in space. When assembly has been completed, it will be possible for seven crew members to live on the ISS for three or more months at a time.

In a real sense, however, there is no reason to think of the space station as ever being "completed." It is a structure that can continue to expand in volume and capability. Modules that are worn or out of date can be exchanged for more advanced replacements. New scientific equipment can continually be added to the laboratories, just as is done on Earth. Entire new technologies, such as nuclear energy for space power production, can be tested *in situ* on, or near, the station.

The permanent manned presence in orbit that the ISS will provide, will also create the opportunity to have smaller experimental or even commercial spacecraft, which need periodic human tending, fly in tandem with the station.

When we are prepared with the knowledge, experience, and developments in science and technology that we need to venture beyond Earth orbit, back to the Moon, and later, to Mars, the International Space Station will take up the task of preparing the crews and testing out the hardware that such exploration will require.

In This Issue:



Probable Route of the Egyptian Voyage in 232 B.C.

AROUND THE WORLD IN THE THIRD CENTURY B.C.

The decipherment of rock and cave inscriptions from the Pacific islands, western New Guinea, and Santiago, Chile, tell of an Egyptian flotilla that set sail around 232 B.C., during the reign of Ptolemy III, on a mission to circumnavigate the globe. The six ships sailed under the direction of Captain Rata and Navigator Maui, a friend of the astronomer Eratosthenes (c. 275-194 B.C.), who headed the famous library at Alexandria. Maui's inscriptions, as translated in the early 1970s by marine biologist and linguist Barry Fell, indicate that this was a proof-of-principle voyage, to demonstrate Eratosthenes' theorem that the world was round, and approximately 24,500 miles in circumference. Marjorie Mazel Hecht reports, in this first of a series of articles on ancient discovery.

EIRNS

THE EURASIAN LAND-BRIDGE: KEY TO SAVING CIVILIZATION

Schiller Institute president Helga Zepp-LaRouche, sharing the podium with former Mexican President José López Portillo, launched a national debate on economic policy in Mexico with a speech at the Mexican Society of Geography and Statistics. Zepp-LaRouche put forward the idea that the policies of transcontinental infrastructure development must replace those of the international monetary institutions.

In the Economics and Development section, Elisabeth Pascali reports on Zepp-LaRouche's intervention, and reviews the existing programs to create a transcontinental transportation grid for Ibero-America.

Helga Zepp-LaRouche's campaign for the Eurasian Land-Bridge, earned her the title of the "Silk Road Lady." Here, she stands near the eastern terminal of the Landbridge in Lianyungang.