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HOW MARIJUANA SOFTENS BRAINS PAGE 59

The Cartesian Formalist Assault on Science

21st CENTURY SCIENCE & TECHNOLOGY

Vol. 10, No. 4 Winter 1997-1998

Features

News

Departments

World population levels for 1997 are lower than those the radical Malthusians demanded in their 1974 tracts about overpopulation, and are expected to crash further (page 12).

On the Cover: Klyuchevskaya, in the Kamchatka peninsula in Russia, at the peak of its eruption, Sept. 30, 1994, as photographed from the Space Shuttle. The black eruption plume, the largest in the past 40 years, billows from the volcano summit, depositing ash on the snow-covered region to the east and southeast. A small steam plume can be seen rising from the peak of Bezymianny, just below the center of the photograph. Photo courtesy of NASA; cover design by Rosemary Moak.

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EDITORIAL

The Lesson of Kyoto: Time to Dump Opportunism

The international conference on climate change policy, held in Kyoto, Japan, in early December, took place in a virtual reality, media-puffed world, where delegates, press, and non-governmental organizations discussed the virtual intricacies of global warming, a problem that does not exist in the real world. Although some of the Kyoto players sincerely believe in this virtual reality, and may even sincerely be alarmed at the virtual disasters involved, many, even among those who recognize that global warming is not real, exhibited that rank disease that is killing science around the world—opportunism.

The opportunism at Kyoto took many forms (see article, p. 84). The industry representatives, for example, never in their many full-page newspaper advertisements or in their news releases, dared to tell the truth about global warming: that the real science of climate, which is based on long-term astronomical cycles, shows clearly that the Earth is coming out of a milder interglacial period and entering a new ice age. Instead, the industry coalition, hoping to bargain for the least hurtful (to them) emissions restrictions, argued that the treaty proposals weren't fair, because the sanctions did not apply equally to the developing sector.

In their turn, the developing nations, including, especially, China, did not publicly attack the lack of science behind global warming, but instead bargained for more time before any emissions-control measures would apply to developing nations. Let the big polluters pay, characterized their opportunistic approach.

The nuclear industry—which should know better after losing its life over the past three decades, because it chose opportunism instead of truth, and pandered to environmentalism—chose opportunism again. Some nuclear advocates, in fact, supported emissions control for fossil fuel plants, citing the known deaths caused by emissions pollution, as a way of promoting clean nuclear power. It is, of course, true that nuclear energy generation is clean, and that fossil fuel emissions pollute, but the overriding fact is that global warming is not real, and that hoping to ride the "emissions pollute" vehicle to the nuclear promised land is guaranteed to fail.

The lesson of Kyoto is that failing to tell the truth about a scientific issue, in the hope of gaining a better position for one's special area of interest (a) cannot work, and (b) relegates science to the dustbin.

Profound Crisis Ahead

This isn't a new problem. Over the past 30 years, this nation, which had become the industrial leader of the world, and had pioneered the leading science and technology of the century, allowed itself to be turned into green mush. Industry, and science, which had lifted the masses of citizens out of poverty, now became the enemy. Little by little, and crisis by crisis, Americans gave in to an artificially created counterculture that aimed to crush its moral and intellectual backbone.

From a nation that fought for freedom and justice, we became a nation that prizes public perception over truth, and equates animal rights, and property rights, with human rights. The uplifting spirit of a scientific, classical culture became buried by an Hollywood- and entertainment-centered culture, and hordes of left and right "thought police," straight out of George Orwell's *1984*.

Today we are entering a period of profound economic and social crisis worldwide. It is very likely that the virtual reality world of global warming, and other such mythologized green issues, will collapse, as economies collapse. The scientific community—scientists, engineers, technologists, and others—can have an important role in determining what road the nation will take at this branch point. But if science is to play a crucial role in rebuilding the nation, and the world, its proponents must wake up, and dump the self-serving opportunism and sheer cowardice that has characterized science over the past three decades. We must fight for the truth—not what is simply "practical," or "acceptable," or "credible," or "fundable," but the truth.

Letters

Injudicious Use of DDT?

To the Editor:

Gee, it's nice to be able to "Preach to the Choir," and have your message received with adulation and applause, *regardless of how wrong-headed or just plain wrong it may be!* I refer to Dr. Tom Jukes's screed to Rachel Carson ("The Truth About Pesticides, or How to Survive the Perils of Living," *21st Century,* Spring 1997, p. 7), or anyone else who does not believe that pesticides in general, and DDT in particular, are planet-saving panaceas, and that anything contravening that Gospel is sacrilege!

How about a few facts, from the memory of an Environmental Chemist who has lived as long as Dr. Jukes, but whose vision is keen, and whose knowledge comes from long study and acquaintanceship with these chemicals in the field, not from some ivory tower.

I give him points for noting the relative non-toxicity of DDT to *humans,* but I note that he does not mention its estrogenic activity. The idea that most bird species increased during the use of DDT is a flat lie, and he knows it. Take away the major food supply, and you're going to have an impact. As for the use of DDT in managing malarial mosquitoes, what a laugh! By the time we had stopped using DDT in this country, most species of mosquitoes had become mithridated to DDT, Enfrin, Aldrin, and a dozen or so other pesticides. . . .

Meanwhile, the good Doctor is correct in another point: it is true that honeybees were relatively immune to DDT (thanks largely to the fact that they had become mithridated; there was a population crash right after the War, but they recovered, mostly due to the importation of Italian bees, our Native species having been nearly wiped out, by DDT, or something). . . .

As for pesticide residues not causing cancer, it entirely depends on where your residues are. There are considerable data to the effect that pesticide applicators have a much higher incidence of every imaginable type of cancer than does the general population; however, if you take the longer, "statistical" (I hate that word—there are liars, damn liars, statisticians, and college professors) approach, you discover that the incidence of cancer in the population generally started to rise about 15 years after the end of World War II, and has incrementally increased ever since, in spite of the feeble attempts of the "Cancer Establishment" to cook the books and show otherwise.

Something caused that increase, and you might as well blame it on chlorinated pesticides as anything else. (I blame it on our agribusiness in general and non-foods in particular!)

I expect that the phosphorothioate and carbamate pesticides will be even more thanatogenic, simply because they murder immune systems, make the person susceptible to whatever comes along.

I realize that by washing Dr. Jukes's clay feet, I will neither please nor convince you, because you, like Dr. Jukes, are immune to the facts, having made up your minds; however, before hailing anything as a panacea, compare the misery it has saved a long-suffering mankind with the misery it has been instrumental in causing.

Sometime after the alleged beneficial use of DDT to eliminate malaria, I was given unshirted Hell by a Hindu professor of mathematics for being an American. When I asked him why he was so down on Americans in general, he said (a direct quote): "We had a nice famine going; it was going to kill 12 million people, and then there would have been plenty for the rest; instead, you stupid Americans brought in grain, and only 3 million died, so now *nobody* has enough to eat!"

Well, he may have overstated the facts a bit, but if we hadn't saved the 12 million people in the first place, by the injudicious use of DDT, maybe there would have been no famine at all. The proper use of ecology is the understanding of consequences, and if you disturb the balance of Nature in one area, she's going to bite you in another. No, I'm no Malthusian; people are not lemmings. However, I point out that we have been in a Red Queen's race throughout my lifetime, and probably a good bit before. What we desperately *need* to do is stabilize the population awhile until we solve the root cause of warfare and man's other myriad inhumanities to mankind.

Given 20 times the population, since human misery seems to increase geometrically, instead of arithmetically, I expect, all else remaining equal, that there would be some 400 times the disease, famine, pestilence, and warfare that there is now. As I say, I expect that one could live in a world like that, but one would not like it very much. In fact, I would predict an inevitable population crash that would make Malthus look like a piker. Murphy's law rules the universe, and the more things there are to go wrong, the more things will go wrong, until people take off their rosy spectacles, and stop dreaming of what things might be like in an ideal world, and start trying to make, each his own little corner of it, if not perfect, at least better every day. . . .

And, taking the long view, the world will be much better off when everyone is a survivor of various plagues. Natural immunity is more effective than killing vectors, because always a few of those survive to breed back. In the long run, only our immune systems can save us, and our efforts should be bent toward strengthening them, rather than declaring war on disease. It's much better never to be sick than to always be looking for a cure, whether you're talking about disease or social ills.

Edward G. Robles, Jr.
Franklin, N.C.

Dr. Thomas Jukes Replies

I have read the long letter by Edward Robles.

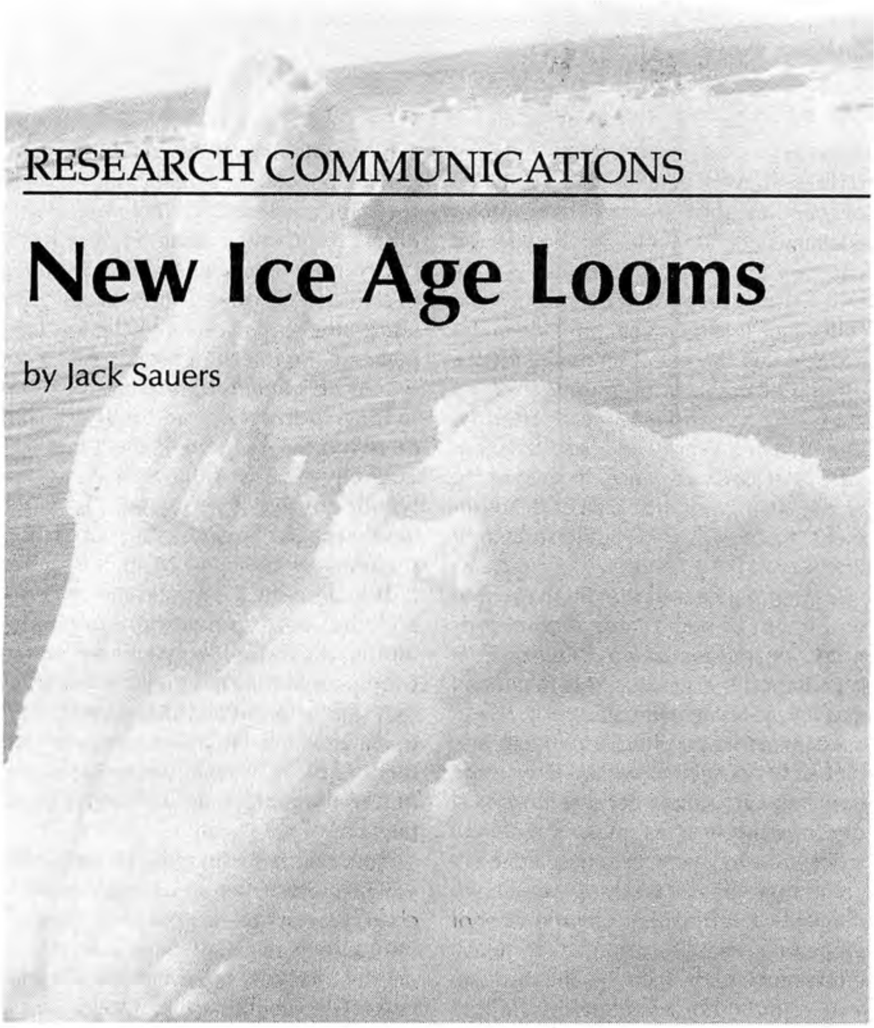
First, some general remarks. Mr. Robles is abusive. For example, he says I have told a lie about chlorination, then he says there are liars, damn liars, statisticians and college professors. He also says I am "immune to the facts." His language tends to be incoherent (see his penultimate paragraph).

His third paragraph says he has lived as long as I have. There is no way of verifying this because he is not listed in the biographical compilations such as *American Men and Women of Science* and *Who's Who in America.* Also there is no

Continued on page 4

New Ice Age Looms

by Jack Sauers



U.S. Coast Guard

Glaciers are growing, the Greenland Ice Sheet is expanding, northern countries have measured a 1°C drop in temperature since 1930, the frost zone has moved farther south—and the know-nothings are scaring people about global warming.

The proponents of the non-science of global warming are fighting the wrong war with their obsolescent computer models. They would be better advised to study how we are even to sustain our current agriculture, energy supply system, and shipping, when the current Little Ice Age gets further advanced. Should there be a still greater rise in vulcanism, and a drop in sunspots and solar output, as I forecast for this next century, we may see a rapid decline of temperatures into the next major glaciation.

At the end of the Eemian Interglacial, 115,000 years ago, it all happened in only 20 years. We have now used up the time of an Interglacial, even if we use the figure of average time for an interglacial of 11,500 years. What we need is real, hard climatic data to track the climatic decline. My wide-ranging review of recent literature has turned up some good clues to this mystery.

The first mercury thermometer weather station was erected in Germany, and gives hard temperature data historically. If we look at the superb little book, *Past Climates, Tree Thermometers, Commodities, and People,* by the late Prof. Leona Libby of the University of California at Los Angeles (the wife of the nuclear scientist Willard Libby, who invented the radiocarbon dating method), we see a graph of "Oxygen Isotope Ratios in a Sequence of German Oaks, 1350 to 1950" (her Figures 2-7, p. 39). The data come from Spessart oaks 1 and 2, and a Marburg oak right next to the mercury thermometer weather stations, against which the oxygen isotope data on cores of the oaks are rigorously calibrated.

Those graphs show that the lowest temperature occurred at about the year 1800. Temperatures then rise to 1930, and have fallen since. The amplitude of the rise from 1800 to 1930 is 1° Celsius. From weather stations in the Alps, and in the Nordic countries, we find the temperature decline since 1930 is also 1° Celsius. Thus, we have to conclude that we are at the temperatures of 1800, *now.* Those were the lowest temperatures ever recorded in the last Little Ice Age, called by students of glacial geology, the Maun-

Letters

Continued from page 3

way of checking his various claims, because he gives no references to the scientific literature.

So what is left of his diatribe? He says, speaking of me, "The idea that most bird species increased during the use of DDT is a flat lie and he knows it." Robles is incorrect. Rachel Carson said the American robin was "on the verge of extinction" in *Silent Spring,* p. 118. She was a propagandist, not an ornithologist. Roger Tory Peterson, the dean of ornithologists, said in 1963 that the robin was probably the most numerous bird on the North American continent (Peterson 1963).

During the last week in each year, the Audubon Society conducts bird counts. The number of robins counted per observer in 1941, before DDT, was 84. In 1960, at the height of DDT usage, the number was 104 (Jukes 1963). The red-winged blackbird underwent a population explosion during the use of DDT, probably because DDT killed the mosquitoes that spread avian malaria (Jukes 1963). It jumped in the Audubon counts from 1.4 million in 1940, to 20 million in 1959 (Marvin 1963). Many other birds in the Audubon counts increased during the use of DDT (Jukes 1963). Malaria was eliminated from the USA by the use of DDT (Simmons, 1959).

Chlorinating the water supply made a great contribution to eliminating typhoid fever, which has become quite rare.

Robles's paragraph about cancer increasing because of pesticide residues is quite incorrect. The legal tolerances for pesticide residues are far below the levels that are carcinogenic (Jukes 1993).

Robles's statement that phosphorothioate and carbamate pesticides "murder immune systems" is unreferenced and is incorrect.

der Minimum. That is why, today, the glaciers at high latitudes are growing, and why we conclude that we are in a new Little Ice Age.

The Effect on Plants

Plants are being greatly affected by this temperature drop, including forests. A comparison of the U.S. Department of Agriculture's own 1965 and 1990 Plant Hardiness Zone Maps, shows that Plant Hardiness Zones have moved southward by one zone, or 10°F, between 1965 and 1990.

Those familiar with the large Bering Glacier in Alaska know that it has been advancing down the valley, in the Chugach Mountains, by as much as 100 to 300 feet per day. You can stand and watch the glacier go by! It has advanced several kilometers in the past few years, and now covers 1,000 square miles.

It has been noted extensively in the press that large numbers of trees in the West are dying from insects and disease, likely as a result of climatic stress, on trees of larger Plant Hardiness Zone numbers at the near limits of their ranges and stability fields.

They advanced upwards with the warming to midcentury, but now are unstable at the higher elevations from the extreme cold, and the increased snowpack conditions.

In Washington state, we had a snowpack 185 percent of normal, in the Cascade Mountains last winter, with almost 19 feet of snow north of Leavenworth, 15 feet on Table Mountain, 60 feet at Stevens Pass, 8 feet at Liberty, and 68 feet at Paradise on Mt. Rainier.

In the Dakotas, there was record cold, record snowfall, and record flooding on the Red River. In northern North Dakota, the pheasant kill was 100 percent; in South Dakota it was 30 percent. There were also tremendously heavy kills for antelope, although deer got by better.

Because of the eastward shifting of the polar vortex on the quasi-biennial polar oscillation cycle, we should see record cold and record snowfall on the eastern seaboard this winter.

Ice Sheet Expanding

Independent data on the growing Greenland Ice Sheet appear in "New Information on Changes in the Greenland Ice Sheet" by H. Jay Zwally of NASA, in *Eos,* published by the American Geophysical Union, Oct. 24, 1989 (p. 1002). Using satellite altimetry, Zwally shows that the Greenland Ice Sheet is increasing in height by 0.2 meters (8 inches) per year, as it extends outward, and that it increases in volume as well.

According to the World Glacier Monitoring Net in Zurich, Switzerland, of the 400 glaciers they monitor, the number of advancing glaciers has gone from 6 percent at midcentury, to 55 percent in 1990. These are the big, high-latitude, maritime glaciers—and they include those in Iceland.

In Iceland, to which I sent perennial rye seed for hardiness testing, the Secretary General of the Ministry of Agriculture wrote in a letter March 10, 1997: "Thank you very much for your letter of 6 Feb. 1997 and the interesting information. Your conclusions are disappointing, naturally, we had been looking so much forward to Global Warming around here; in fact, we hardly can wait."

In the Ministry's brochure, "Agriculture in Iceland," a graph of the temperature above that of pack ice around Iceland shows that it reached a peak at midcentury, and has fallen since—as pack ice in the North Atlantic has been advancing southward with the increasingly cold northern Arctic Ocean.

Ice Volume Increase

Temperatures from all of the Nordic countries have undergone a decline of 1° Celsius since 1930, the temperature high for this century (see my letter-to-the-editor, *21st Century,* Summer 1997, p. 5).

The GISP-2 U.S. drilling in Greenland, and the European GRIP drilling there, both show the temperature decline in Greenland since midcentury in oxygen isotope temperature data, as published by M. Stuiver, et al. in numerous papers ("The GISP-2 O-18 Climate Record of the Past 16,500 Years and the Role of the Sun, Oceans, and Volcanoes," *Quaternary Review,* Vol. 44, pp. 341-354, 1995). That temperature decline is synynchronous with the one in Antarctica, as published in *Nature* by W. Dansgaard et al., from Vostok core data ("Evidence for General Instability of Past Climate for a 250 kyr Ice Core Record," *Nature,* Vol. 364, pp. 218-220, 1995). The Russians went broke, so the United States finished the drilling. (Historically, currencies collapse in Little Ice Ages, too.)

Meanwhile, in Antarctica, a massive increase in ice volume is under way, because temperatures have fallen there, as ice core data show. For ice volume in Antarctica, Prof. Charles Bentley of the Center for Climatic Studies at the Uni-

Continued on page 7

He says, "If we hadn't saved the 12 million people by the injudicious (!) use of DDT, maybe there would have been no famine at all." In the first place, this statement is genocidal. In the second place, DDT increased the food supply by protecting crops, thus helping to prevent famine (Simmons 1959).

His penultimate paragraph makes a lot of unsubstantiable claims. For example, saying that the world will be much better off when everyone is a survivor of various plagues.

Finally, "DDT has saved more lives and prevented more disease than any chemical in history except perhaps, the antibiotics" (Simmons 1959). And the only sickness caused by DDT was when it was used by mistake for pancake flour (Simmons 1959).

Thomas H. Jukes
Professor Emeritus of Biophysics
Space Sciences Laboratory
University of California at Berkeley

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Editor's Note

Dr. Tom Jukes, a biochemist, has been fighting to publicize the truth about DDT since the 1970s. His research and publications have included work on the B vitamins, the growth-promoting effects of antibiotics, the amino acid code, molecular evolution, and methotrexate, the first compound used to treat leukemia in children. Jukes, now 91, has published scores of technical articles on the subject of nutrition, pesticides, and chemicals, and several of his articles written for nonspecialists have appeared in *21st Century*.

'Neanderthal Flute' in Tune with Classical Diatonic World

by David M. Shavin

It now appears that it is an insult to call Schoenberg, or any modernist, atonal composer, a "Neanderthal"—an insult, that is, to the Neanderthals!

In July 1995, Dr. Ivan Turk, a paleontologist at the Slovenian Academy of Sciences, located a fragment of a bear's femur, carved with two full holes and two fragmented holes. Turk sent it, and other items, to geologist Bonnie Blackwell, at Queens College in New York City, for purposes of dating. Blackwell dated the flute fragment as being between 43,400 and 67,000 years old.

Canadian musicologist Bob Fink analyzed photographs of this flute, provided by Blackwell, and has circulated his February 1997 "Neanderthal Flute" analysis on the Internet (http://www.webster.sk.ca/greenwich/fl-compl.htm).

Fink's conclusion is as follows:

"*The distance between holes 2 and 3 is virtually twice that between holes 3 and 4. . . .* This means we are looking at a whole-tone and a half-tone somewhere within a scale. Such a combination of whole-tone and half-tone is the heart and soul of what makes up 7-note diatonic scales. *Without making even one more measurement* beyond this, we can already conclude: *These three notes on the Neanderthal bone flute are inescapably diatonic and will sound like a near-perfect fit within* any *kind of standard diatonic scale, modern or antique* . . . . In essence, the whole story is simply that" [emphasis in original].

Dr. Turk is reported to be conducting a micro-analysis of the holes of the flute, to compare them with the type of cutting tools found at the Slovenian site.

The World of Bach and Mozart

The four notes, being spaced as "whole-step, whole-step, half-step," places our Neanderthal flutist in the diatonic world, normally associated with that of Bach and Mozart. The prized disorder of ethno-musicologists—who could not even allow a diatonic spacing in the classical Greek tetrachord of 2,500 years ago—is now shattered by diatonic ordering evidenced at least 41,000 years earlier than the Greeks.

Fink points to similar evidence of the use of the diatonic scale in what he called the "world's oldest known song," written on 4,000-year-old clay tablets from Ur, and deciphered by Professor Anne Kilmer, head of the Department of Assyriology at the University of Califor-

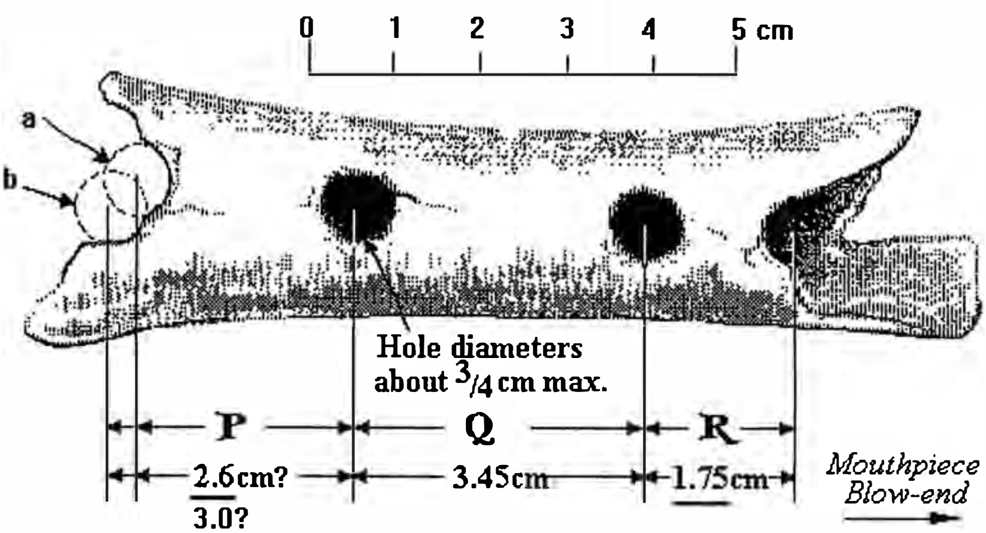


Figure 1
SCHEMATIC OF THE NEANDERTHAL FLUTE
The holes on the ends were not as well defined as the two holes in the middle, so the distance between the middle holes was used as the standard. Fink's analysis concludes that the notes on this flute, if possible for it to reach the total air column length of about 42 cm, are consistent with four notes of the minor diatonic scale. All the notes, he says, are still within the general pitch range able to be considered as notes within the diatonic scale.

Source: Bob Fink

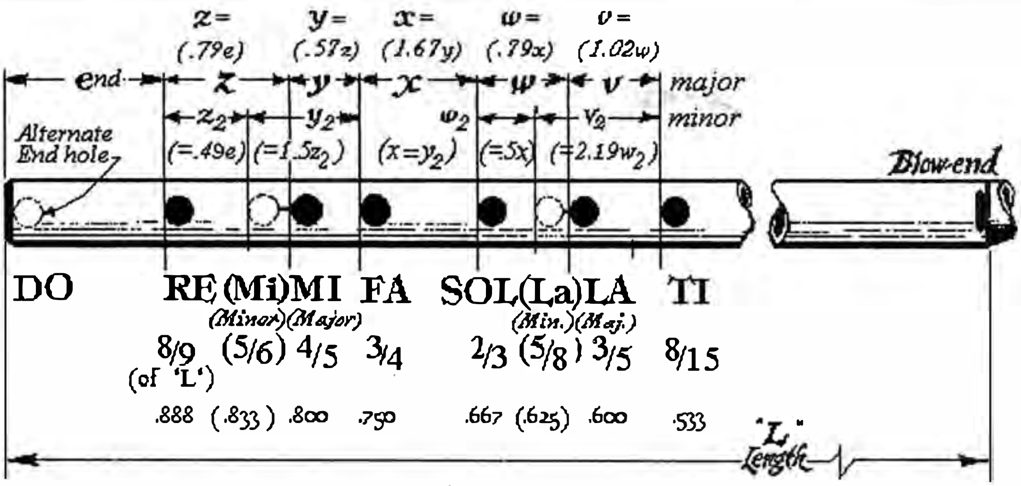


Figure 2
A MODEL FLUTE

The general way in which a flute is made to produce a major diatonic scale is (1) to divide the total length of the flute so that, from the blow end, if no holes are punched, the flute will produce its fundamental note—do, on the do-re-mi scale. A hole made at 8/9ths of the air column, measuring from the blow end, will then give the second note on a rising scale, re. Another hole, 4/5 from the mouthpiece, produces the third note, mi. Holes at 3/4, 2/3, 3/5, and 8/15 complete the scale, and more holes after that, in similar relationships, will repeat the scale an octave higher.

Source: Bob Fink

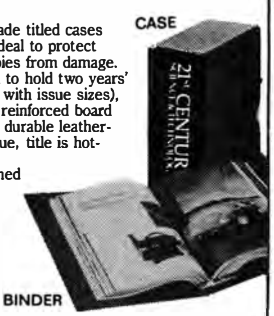
nia at Berkeley.

In a recent discussion with this author, Fink was at some pains to defend himself from attacks from ethno-musicologists for imposing "Western" values upon all musical cultures. He characterized his position by saying the evidence for the diatonic scale is so solid that the "diatonic is not 'Western,' but universal."

The Universal Diatonic

The two half-notes of the diatonic scale call attention to two singular orientations in the scale. In the most basic diatonic scale, the major scale (for example, C-major), the two half-notes (at E-F and B-C) place in apposition, two similar tetrachords (C-D-E-F and G-A-B-C). This fundamental structure of apposition is characteristic of the "dialogue" structure of classical Greek. More generally, it can be said to be characteristic of human culture, of thought, speech, song, and problem-solving.

Hence, for this feature to be evidenced where a species creates tools, should not be so shocking. The truly shocking feature is that ethno-musicologists, and anthropologists with a similar bent, could spend so much time not recognizing their own shadow.



The Ice Age Looms

Continued from page 5

versity of Wisconsin, estimates growth of the Antarctic Ice Sheet at 200 gigatons per year ("Antarctic Mass Balance and Sea Level Change," *Eos,* Dec. 14, 1993, p. 585 ff). That would produce a sea-level lowering of about 0.5 mm per year. Since 1930, that would come to about 3.3 cm, exclusive of effects from the other growing glaciers, like the one in Greenland.

So, should we worry about the melting of the ice caps from the non-science of global warming, when the ice caps are actually growing, and sea level is falling?

Since the Climatic Optimum 4,000 to 6,000 years ago, the general trend has been a falling sea level, which has left high-elevation terraces around the world, and growing ice caps. Maybe we should consider what will happen when the ports of the world will be left high and dry! And, I guarantee that they will.

It is interesting that empires have collapsed during the Little Ice Ages in our Holocene Interglacial, and we can name them: the Sumerian, the Egyptian, the Greek, and the Roman.

Jack Sauers has been a geologist since 1949, and is currently working as an independent consultant.

A New Nuclear Paradigm

Sen. Pete V. Domenici, a New Mexico Republican, has served in the U.S. Senate since 1972. This viewpoint is adapted from his speech at the inaugural symposium at the Belfer Center for Science and International Affairs, Harvard University, Oct. 31, 1997.

by Sen. Pete V. Domenici

Strategic national issues just don't command a large audience. In no area has this been more evident during these last 25 years than in the critical and interrelated public policy questions involving energy, growth, and the role of nuclear technologies. As we leave the 20th century, arguably the American Century, and head for a new millennium, we truly need to confront these strategic issues with careful logic and sound science.

We live in the dominant economic, military, and cultural entity in the world. Our principles of government and economics are increasingly becoming the principles of the world.

There are no secrets to our success, and there is no guarantee that, in the coming century, we will be the principal beneficiary of the seeds we have sown. There is competition in the world and serious strategic issues facing the United States cannot be overlooked.

The United States, like the rest of the industrialized world, is aging rapidly as our birth rates decline. Between 1995 and the year 2030, the number of people in the United States over age 65 will double from 34 million to 68 million. Just to maintain our standard of living, we need dramatic increases in productivity as a larger fraction of our population drops out of the workforce.

By 2030, 30 percent of the population of the industrialized nations will be over 60. The rest of the world, the countries that today are "unindustrialized," will have only 16 percent of their population over age 60 and will be ready to boom.

As those nations build economies modelled after ours, there will be intense competition for the resources that underpin modern economies.

When it comes to energy, we have a serious, strategic problem. The United States currently consumes 25 percent of the world's energy production. However, developing countries are on track to increase their energy consumption by 48 percent between 1992 and 2010.

The United States currently produces and imports raw energy resources worth over $150 billion per year. Approximately $50 billion of that is imported oil or natural gas. We then process that material into energy feedstocks such as gasoline. Those feedstocks, the energy we consume in our cars, factories, and electric plants, are worth $505 billion per year.

Energy Policy Not Debated

So, while we debate defense policy every year, we don't debate energy policy, even though it already costs us twice as much as our defense, other countries' consumption is growing dramatically, and energy shortages are likely to be a prime driver of future military challenges.

When I came to the Senate a quarter of a century ago, we debated our dependence on foreign sources of energy. We discussed energy independence, but we largely decided not to talk about nuclear policy options in public.

At the same time, the anti-nuclear movement conducted their campaign in a way that was tremendously appealing to mass media. Scientists, used to the peer-reviewed ways of scientific discourse, were unprepared to counter. They lost the debate.

Serious discussion about the role of nuclear energy in world stability, energy independence, and national security retreated into academia or classified sessions.

Today, it is extraordinarily difficult to conduct a debate on nuclear issues. Usually, the only thing produced is nasty political fallout.

I am going to bring back to the marketplace of ideas a more forthright discussion of nuclear policy.

Bad Past Decisions

My objective tonight is not to talk about talking about a policy. I am going to make some policy proposals. . . . I am going to tell you that we made some bad decisions in the past that we have to change. Then I will tell you about some decisions we need to make now.

First, we need to recognize that the premises underpinning some of our nuclear policy decisions are wrong. In 1977, President Carter halted all U.S. efforts to reprocess spent nuclear fuel and develop mixed-oxide fuel (MOX) for our civilian reactors on the grounds that the plutonium could be diverted and eventually transformed into bombs. He argued that the United States should halt its reprocessing program as an example to other countries, in the hope that they would follow suit.

The premise of the decision was wrong. Other countries do not follow the example of the United States if we make a decision that other countries view as economically or technically unsound. France, Great Britain, Japan, and Russia all now have MOX fuel programs.

This failure to address an incorrect premise has harmed our efforts to deal with spent nuclear fuel and the disposition of excess weapons material, as well as our ability to influence international reactor issues.

I'll cite another example. We regulate exposure to low levels of radiation using a so-called "linear no-threshold" model, the premise of which is that there is no "safe" level of exposure.

Our model forces us to regulate radiation to levels approaching 1 percent of natural background despite the fact that natural background can vary by 500 percent within the United States.

On the other hand, many scientists think that living cells, after millions of years of exposure to naturally occurring radiation, have adapted such that low levels of radiation cause very little if any harm. In fact, there are some studies that suggest exactly the opposite is true—that low doses of radiation may even improve health.

The truth is important. We spend over $5 billion each year to clean contaminated Department of Energy sites to levels below 5 percent of background.

In this year's Energy and Water Appropriations Act, we initiated a 10-year program to understand how radiation affects genomes and cells so that we can really understand how radiation affects living organisms. For the first time, we will develop radiation protection standards that are based on actual risk.

Let me cite another bad decision. You may recall that earlier this year, Hudson Foods recalled 25 million pounds of beef, some of which was contaminated by E. coli. The Administration proposed tougher penalties and mandatory recalls that cost millions.

What you may not know is that the E. coli bacteria can be killed by irradiating beef products. The irradiation has no effect on the beef. The Food and Drug Administration does not allow the process to be used on beef, even though it is allowed for poultry, pork, fruit, and vegetables, largely because of opposition from some consumer groups that question its safety.

But there is no scientific evidence of danger. In fact, when the decision is left up to scientists, they opt for irradiation. The food that goes into space with our astronauts is irradiated.

I've talked about bad past decisions that haunt us today. Now I want to talk about decisions we need to make today.

Nuclear Decisions Needed

The President has outlined a program to stabilize the U.S. production of carbon dioxide and other greenhouse gases at 1990 levels by some time between 2008 and 2012. Unfortunately, the President's goals are not achievable without seriously impacting our economy. . . . What the President should have said, is that we need nuclear energy to meet his goal. After all, in 1996, nuclear power plants prevented the emission of 147 million metric tons of carbon, 2.5 million tons of nitrogen oxides, and 5 million tons of sulfur dioxide. Our electric utilities' emissions of those greenhouse gases were 25 percent lower than they would have been if fossil fuels had been used instead of nuclear energy.

Ironically, the technology we are relying on to achieve these results is over 20 years old. We have developed the next generation of nuclear power plants which have been certified by the Nuclear Regulatory Commission and are now being sold overseas. They are even safer than our current models. Better yet, we have technologies under development like passively safe reactors, lead-bismuth reactors, and advanced liquid metal reactors, that generate less waste and are proliferation resistant. . . .

We are realizing some of the benefits of nuclear technologies today, but only a fraction of what we could realize. . . . Nuclear power is providing about 20 percent of our electricity needs now, and many of our citizens enjoy healthier longer lives through improved medical procedures that depend on nuclear processes.

But we aren't tapping the full potential of the nucleus for additional benefits. In the process, we are short-changing our citizens.

I hope in these remarks that I have succeeded in raising your awareness of the opportunities that our nation should be seizing to secure a better future for our citizens through careful reevaluation of many ill-conceived fears, policies, and decisions that have seriously constrained our use of nuclear technologies.

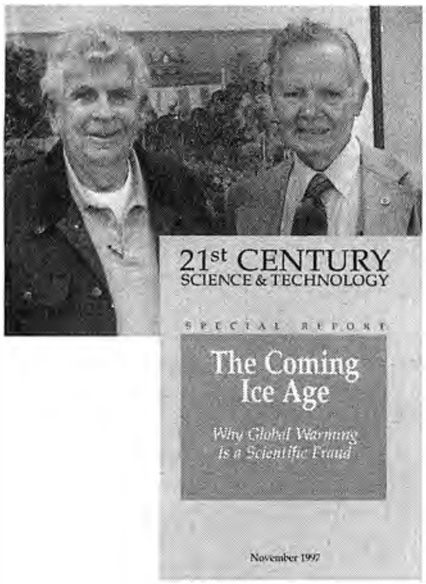
Today I announce my intention to lead a new dialogue with serious discussion about the full range of nuclear technologies. I intend to provide national leadership to overcome barriers.

While some may continue to lament that the nuclear genie is out of his proverbial bottle, I'm ready to focus on harnessing that genie as effectively and fully as possible, for the largest set of benefits for our citizens.

I challenge all of you to join me in this dialogue to help secure these benefits.

NEWS BRIEFS

Warren Quesnel/EIRNS



Telling the truth about the global warming fraud: 21st Century *scientific advisory board members Stevenson (left) and Ellsaesser.*

ELLSAESSER, STEVENSON RELEASE GLOBAL WARMING REPORT

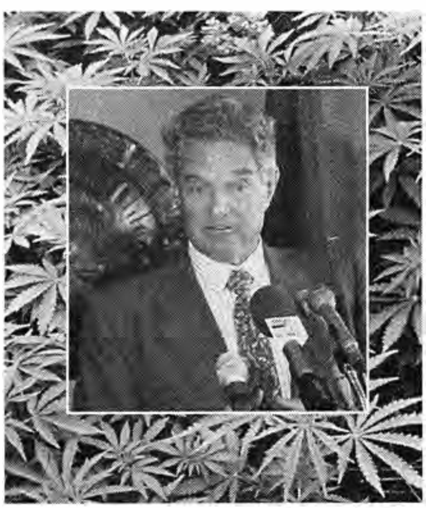
21st Century's special report, "The Coming Ice Age: Why Global Warming Is a Scientific Fraud," was released at a Nov. 21 press conference in San Diego, by atmospheric scientist Hugh Ellsaesser and oceanographer Robert Stevenson, who authored articles in the report. Among the audience were several *21st Century* subscribers, and reporters from the NBC-TV affiliate, KOGO radio, and Channel 39. "We are close to the point where we should expect 90,000 years of cooling," and not global warming, Ellsaesser said, and "we should give serious consideration to increasing CO_2 release into the atmosphere to prevent a new Ice Age." Stevenson accused proponents of global warming of "prostituting their science," and said that when he wrote this in *21st Century,* he expected nasty responses, but instead got more than 150 letters from scientists worldwide congratulating him.

Both scientists reviewed the frauds of the global warming "science." The KOGO reporter, who taped the discussion, asked, "How the hell do we get this across to the population?"

GOOD NEWS FOR MEAT EATERS: FDA APPROVES RED MEAT IRRADIATION

The Federal Food and Drug Administration Dec. 2 approved the use of low-dose irradiation to rid beef and lamb of disease-causing microorganisms. In announcing its decision, the FDA stated: "This approval is based on FDA's thorough scientific review of a substantial number of studies conducted worldwide on the effects of irradiation on a wide variety of meat products. The studies included examination of the chemical effects of radiation, impact on nutrient content of irradiated products, potential toxicity concerns, and effects on microorganisms in or on irradiated products. FDA concluded that irradiation is safe in reducing disease-causing microbes in or on meats, and that it does not compromise the nutritional quality of the food."

Now it's up to consumers to demand that supermarkets carry irradiated products.



Stuart Lewis/EIRNS

The moneybags for drug legalization and megaspeculation, George Soros. His Washington state pot initiative lost Nov. 4.

GERMAN-LANGUAGE EDITION OF *THE MANIC SUN* PUBLISHED

Dr. Böttiger Verlag, the publisher of the German-language translation of *21st Century's The Holes in the Ozone Scare,* released a German-language version of *The Manic Sun,* by British science writer Nigel Calder, at a press conference in Bonn Oct. 22. Calder's book is based on research by Danish scientists who have identified the Sun as the primary factor in climate change. Their specific discovery pinpoints the action of cosmic rays as a generator of clouds, and the ability of the Sun, depending on its "manic" or "depressive" magnetic phase, to reduce or increase the number of cosmic rays that reach the Earth. The release of the book coincided with the opening of the climate change treaty discussions in Bonn. A review of the Calder book, which is published in London by Pilkington Press, will appear in a coming issue of *21st Century.*

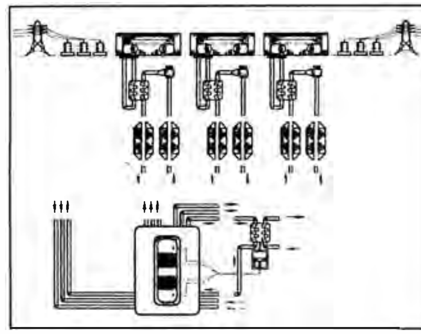
LEGALIZED DOPE INITIATIVE FLOPS IN WASHINGTON STATE

Washington state voters defeated financier-speculator George Soros and his drug legalization campaign Nov. 4, voting down the "medical marijuana" initiative by a margin of 60 to 40 percent. Soros and his two partners, who had funded the Arizona and California initiatives last year, put more than $1.5 million into Washington State's Initiative 685. Although opponents of the initiative spent only $100,000, they mustered high-profile, bipartisan opposition, bringing into the state Clinton drug policy adviser Gen. Barry McCaffrey (ret.) and William Bennett, who held that post in the Bush administration.

NEW BURN-WAVE FISSION REACTOR PROPOSED BY EDWARD TELLER

A new fission reactor concept, the "burn-wave" reactor, was presented by Dr. Edward Teller at the International Conference on Environment and Nuclear Energy, held in Washington, D.C., in October. The revolutionary design uses a small, 20-percent-enriched igniter assembly of uranium, placed in the center of a cylinder of 75 to 100 tons of thorium, or unenriched uranium. When the igniter is allowed to go critical, it generates a fission burn-wave that moves down the cylinder toward both ends. Fast neutrons from the burn wave then breed new fissile fuel in the thorium, which, in turn, reproduces the igniter region. In this way, as the igniter burns up, a new igniter region is generated in front of it—a self-sustaining burn-wave. The new reactor produces the same amount of energy as a conventional nuclear reactor, but uses only 100 tons of fuel, compared with the conventional reactor's 3,000 to 4,500 tons. Also, there is a greater burn-up of the fission fuel—more than 50 percent.

Dr. Teller proposes that the reactor be buried 100 meters below ground, where the vessel could serve as its own spent-fuel burial cask, after it completes its useful life. A more detailed report on the reactor will appear in the next *21st Century.*



Lawrence Livermore National Laboratory

BURN WAVE REACTOR SCHEMATIC

The underground burn-wave reactor has several novel safety features, including a highly redundant, distributed thermostatic control of the core temperature and triple-redundant, entirely passive after-heat transport.

U.S. GREENIE MURDERER EINHORN PROTECTED IN FRANCE

Convicted murderer Ira Einhorn, one of the founders of "Earth Day," 27 years ago, was apprehended in France in September, but the French are fighting his extradition. Einhorn was arrested in 1979, after his Philadelphia neighbors complained of a foul smell coming from his apartment. Police then found the body of his girlfriend, Holly Maddux, stuffed in a trunk in a closet, where it had decomposed. Einhorn jumped bail before his trial for murder, and was convicted in absentia by a Philadelphia jury in 1993 and sentenced to life imprisonment.

For details of Einhorn's high-level support network, including Charles and Barbara Bronfman, see *21st Century's The Holes in the Ozone Scare: The Scientific Evidence That the Sky Isn't Falling,* Chapter 9 on "The Corporate Environmentalists."

U.S. TO DEMOLISH DAM IN MAINE TO PROTECT FISH

For the first time in U.S. history, the Federal Energy Regulatory Commission (FERC) has ruled that a dam, the Edwards Dam in Augusta, Maine, will not be relicensed, and will be demolished. The reason? The dam allegedly hinders the migratory passage of sturgeon, salmon, and other fish. The Edwards Dam, 160 years old, is a small facility that produces only 3.5 MW of electricity, most of it going to its owner, the Edwards Manufacturing Company. However, the precedent that this sets could put hundreds of other hydroelectric dams, whose licenses are coming up for review, at risk. Within the next 15 years, there are 550 such dams, most larger than Edwards. FERC based its ruling on a 1986 law requiring that FERC decisions must balance conservation, recreation, and other environmental "values" with social and economic considerations. Because it would have cost more to put fish passages through the dam, than to tear it down, FERC rationalized, on a cost-benefit basis, that the dam should come down.

Chlorine is the salt of the Earth, both literally and figuratively. In its most abundant state, chlorine is found as sodium chloride, or table salt.

CHLORINE CALENDAR AVAILABLE FROM CHLORINE CHEMISTRY COUNCIL

The Chlorine Chemistry Council has produced an attractive four-color 1998 calendar, with 12 months of photographs and facts illustrating how chlorine is a basic element of life. Copies are available, while they last, from the council at (703) 741-5000.

DEATH RATES UP, BIRTH RATES DOWN

The Near-Term Danger of World Population Implosion

by Paul Gallagher

UNICEF

The population growth rate of the human species has been slowing down worldwide since the 1970s, and slowing dramatically since the later 1980s; the decline in annual population growth has become sharper with the passage of each 3- to 5-year period. This is now generally acknowledged by the United Nations Fund for Population Activities (UNFPA) and the Malthusian non-governmental organizations (NGOs) which swarm under its umbrella—all of which are exulting at this "more rapid than expected" slowdown. The more radical among them—like the U.S. State Department-linked Negative Population Growth, and its university "scholars" such as Cornell's David Pimentel and Kenyon College's J. Donald Smail—now call for the human race to devolve 500 years, to a total of 500 million individuals.

Where is this leading? Unless there is worldwide economic reconstruction and improvement in living conditions, based on a fundamental shift in the economic and cultural axioms behind the current "global," one-world policies, the world's population will start to decline within 15 years. And if these global policies continue, there will be a dramatic collapse, or implosion, of world population, through war, famine, and disease. This reality lurks as an ominous singularity, within the now undeniable trend of rapidly shrinking population growth rates.

The situation is like that of the terrible 14th century: After 600 years of steady (although slow) growth in world population, that growth was halted in the later part of the 13th century, under the impact of usury in Europe, and Mongol genocide in the East. Then, after just a few decades of ominous "equilibrium," human numbers plunged by 20 percent in the Black Death from 1300 to 1400 A.D.

The science of physical economy based on measures of *relative potential population density,* developed and presented by Lyndon LaRouche, Jr., in *The Science of Christian Economy* and many other works, establishes the causality of the threatening population implosion, as well as the economic/cultural changes which can avert it.[1]

NSSM 200

The now notorious U.S. National Security Study Memorandum 200, known as NSSM 200, was a secret document issued in 1974, by which self-professed British agent-of-influence Henry (now Sir Henry) Kissinger, and his Deputy National Security Advisor, Gen. Brent (now Sir Brent) Scowcroft, attempted to commit the United States to a policy of stopping population growth worldwide. Against U.S. National Security Council regulations, this document was kept secret until 1990, when it was obtained by an Islamic publication in the United States. In 1991, NSSM 200 was exposed internationally by LaRouche's Executive Intelligence Review News Service.

NSSM 200 targetted 13 large Third World countries, whose development prospects were connected to their population potential, as countries whose population growth the United States had to intervene to stop. These were: India, Pakistan, Bangladesh, Indonesia, the Philippines, Thailand, Nigeria, Egypt, Ethiopia, Mexico, Brazil, Colombia, and Turkey. These nations, stated NSSM 200, accounted for "47 percent of world population increase." Leaving aside China—which already in 1974 had a one-child-per-family policy—these 13 countries' share of the world population increase was nearly 60 percent.

Outrageously, Sir Henry's document claimed that:

"The political consequences of current population factors in the LDC's [Less-Developed Countries] are damaging to the internal stability and international relations of countries in whose advancement the U.S. is interested, thus creating political or even national security problems for the U.S."

Sir Henry's original directive for NSSM 200 had warned of "the trade problems the U.S. may face arising from competition for resources . . . [and] the likelihood that population growth or imbalances will produce disruptive foreign policies and international instability."

The Memorandum itself asserted: "World population growth is widely recognized within the government as a current danger of the highest magnitude, calling for urgent measures. . . . [O]ur aim should be for the world to achieve a replacement level of fertility (a two-child family on average), by the year 2000. This will require the present 2 percent [annual] growth rate to decline to 1.7 percent within a decade, and to 1.1 percent by 2000. Compared to the U.N. medium projection, this goal would result in 600 million fewer people in 2000. . . . Attainment of this goal will require greatly intensified population programs."[2]

It is under the policy-direction of this document, that the U.S. Agency for International Development has funded the voluntary, and involuntary, sterilization of 22 to 26 million Brazilian women, the massive sterilization/contraception campaign in Thailand, and other invasions of the sovereignty of Third World nations.

The NSSM 200's "U.S. Proposed Goals for the World Population Plan of Action," show that the memo was nothing but implementation of the United Nations World Population Conference, held in Bucharest in 1974, where that "Plan of Action" was put forward by John D. Rockefeller II, Margaret Mead, and other enemies of human population. In Bucharest, Helga Zepp-LaRouche enraged the conference leaders, by denouncing them for their genocide plan.

The 'Impossible' Results

In 1974, the U.N. Population Commission, now the U.N. Fund for Population Activities, had only recently begun its "high, medium, and low" projections of the global human population. The "high forecast" then was the projection of existing growth rates into the future; the "medium forecast" assumed the imposition ("adoption") by nations of antinatalist policies being promoted by U.N. agencies, and so on; the "low forecast" was a Malthusian target, but considered politically and culturally impossible.

But the NSSM 200 policy document went even further; it aimed to cut 600 million lives off the U.N. medium projection, and leave the year-2000 population *slightly below the U.N.'s "low" projection.* What this meant was as follows: If 1974 fertility, worldwide, had remained the same, there should have been 7.8 billion people alive by 2000; fertility was then 38 births per 1,000 people per year. If this rate were brought down to 29 births per 1,000 by the year 2000, NSSM 200 forecast that the resulting population would reach only 6.5 billion. Finally, according to NSSM 200, if worldwide fertility could be *cut in half,* to 21 births per 1,000, the year-2000 population could be held to 5.93 billion.

This was the "impossible" Malthusian target. As we see below, on a country-by-country basis, Sir Henry's National Security Council staff, and the demographers they consulted, considered it impossible. But it is, nearly exactly, what the world population (now reportedly 5.84 billion) *will be* in the year 2000!

This "impossible" goal was achieved by the Bucharest Conference genocidalists, not by reducing worldwide fertility to 21 births per 1,000 (the fertility rate is still 25 percent above that), but by increasing death rates—lowered life expectancies.

The "ideal" low-ball goals adopted for the year 2000 by both NSSM 200 and the 1974 Bucharest U.N. Population Conference, region by region, are compared in Table 1 to mid-1997 population data reported by the U.N. and the U.S. Bureau of Census. Now look at the country-by-country targets in Table 2, established by the NSSM 200 Report.

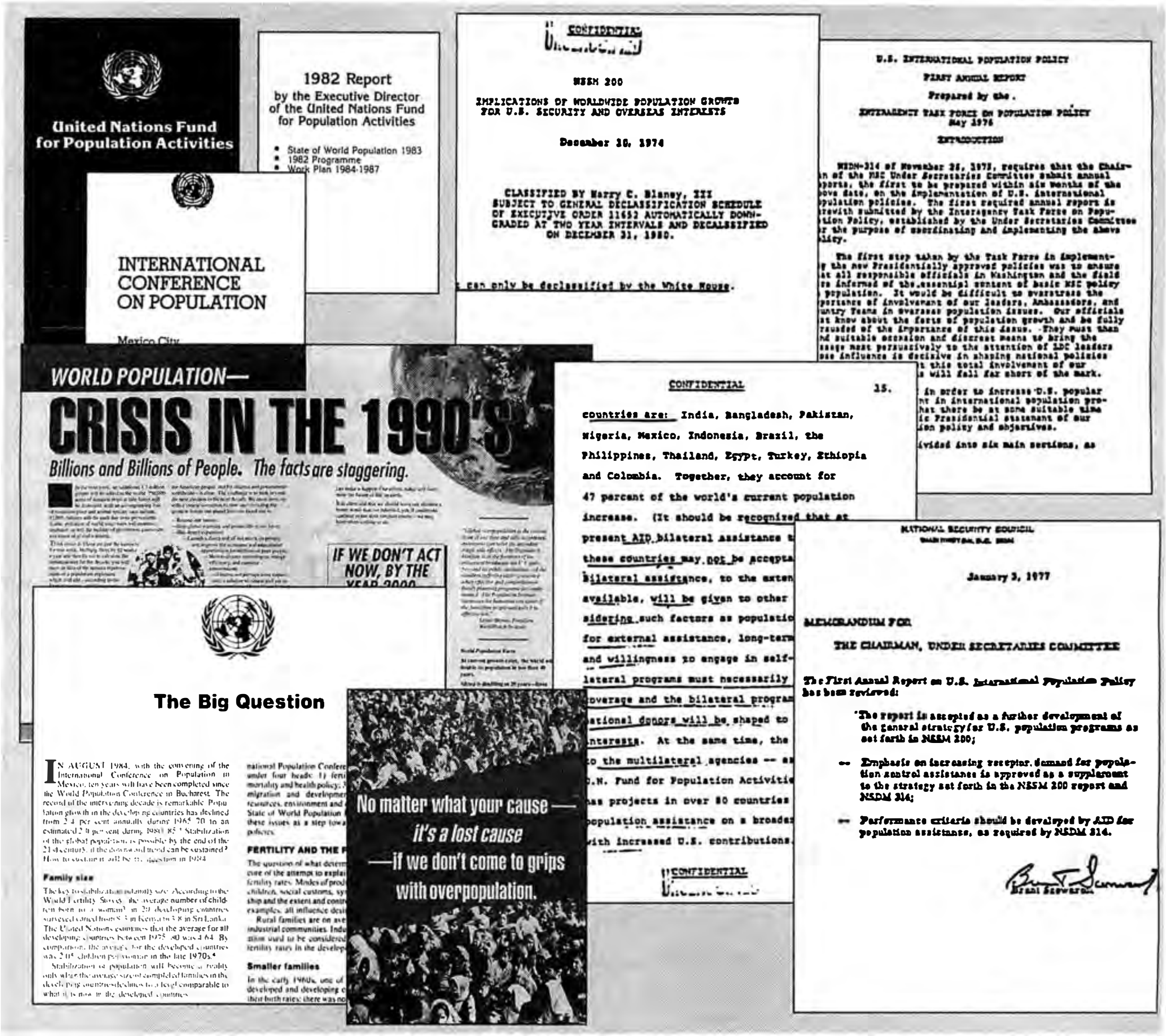
Table 1
1974 IDEAL GOALS OF THE MALTHUSIANS COMPARED TO 1997 POPULATION DATA
(in millions)

	1974 Malthusian target for 2000	Actual mid-1997 reported population
World	5,930	5,840
"More Developed" Industrial Countries	1,430	1,400
Ibero-America	500	492
Africa	600	750
East Asia	1,400	1,400
South & SE Asia	2,000	1,810

Table 2
1974 IDEAL GOALS OF THE MALTHUSIANS FOR 7 TARGETTED NATIONS COMPARED TO 1997 POPULATION DATA
(in millions)

Targetted nations	NSSM 200 objective for year 2000	Actual mid-1997 reported population
Venezuela	22	22
China	1,200	1,210
Indonesia	214	203
Morocco	35	27.5
Mexico	100	94
Bangladesh	145	122
Nigeria	127	118*

* 107 million according to the U.S. Census Bureau.



Population growth rates have now been reduced to below the level that, in the 1970s and 1980s, these Malthusian maniacs considered impossible to achieve. At right are pages from NSSM 200.

Again, these are its ultimate objectives for these "targetted" nations for the year 2000.

• About Mexico, NSSM 200 claimed: "Even under the most optimistic conditions, in which the country's average fertility falls to replacement level by 2000, Mexico's population is likely to exceed 100 million by the end of this century."

Mexico's fertility rate is still above the "replacement" level of 2.2 to 2.4 children per fertile woman for developing countries (it is 2.75). Yet its population in 2000 will be below the level Sir Henry's planners considered an impossibly low target.

• About Bangladesh, the NSSM 200 Report came bluntly to the Malthusian point: "[U]nless slowed by famine, disease, or massive birth control programs, the population of Bangladesh will double to over 170 million by 2000." As late as 1987, the U.S. Bureau of Census forecast of national populations projected 145 million Bangladeshis by the year 2000 (then only 13 years off). Yet, today's Bangladesh population is reported as only 122 million!

• For Egypt, NSSM 200 projected as *most probable,* a population of 84 million in 2000. Today, in fact, Egypt's population is only 64.5 million.

• For Brazil, a population of 212 million in 2000 was projected (appropriate to the development of Brazil into a major power). Instead, Brazil's population today is reportedly 163 million. And 22 to 26 million Brazilian women have been sterilized, many unknowingly or coercively, under programs stemming from NSSM 200.

The population of the 13 countries targetted by NSSM 200, then, are falling 20 to 30 percent below the U.N. forecasts of a generation ago. Most have fallen below even the "low variant" projections of 1974's population-cutting plans—"low variants" which were thought impossibly low at that time, even by the zero population growth mafia.

Moreover, in 1987, only a decade

ago, the U.S. Census Bureau's official projections of national populations for the year 2000, was grossly overestimating these nations' growth (see Table 3).

Global Forecasts Plunge

Consider the following patterns of decline in world population estimates since the 1950s:

- The earliest forecasts for the year-2000 world population were made more than 40 years ago by the U.S. Bureau of Census and the U.S. Atomic Energy Commission. They estimated, for purposes of projecting electrical energy consumption, that 8 billion people would be alive by, roughly, the beginning of the new millennium.
- In 1969, when President Richard Nixon created the Rockefeller Commission on population growth, he stated to Congress, "If this rate of population growth continues, it is likely that the Earth will contain 7 billion human beings by the end of the century."
- In December 1974, when NSSM was completed under Sir Henry and Sir Brent, it adopted the then-current U.N. "middle variant" forecast of 6.5 billion by the year 2000 (and the "low variant" of 5.93 billion as its "impossible" ultimate target).
- By 1987, the U.S. Bureau of Census forecast a world population of 6.3 billion in the year 2000.

Thus, nearly 2 billion individuals gradually disappeared from the forecasts over 30 years. It is now clear that the human population, in 2000, will not exceed 6 billion human beings.

What about longer-range prognoses? The next benchmark is the year 2025. NSSM 200 forecast a human population of 10 billion by 2025 (then 50 years away). The 1987 U.S. Census Bureau Report forecast 8.7 billion for the same year (then 38 years distant). Then, at the 1992 global circus known as the Rio Conference, or the U.N. Conference on the Global Environment, the UNFPA gave a new "middle variant" estimate of 8.5 billion. Today, only five years later, the UNFPA's report, "The State of the World Population 1997," forecasts—for the same year 2025, now fewer than 30 years in the future—a world population of 8.0 billion people.

Thus, "authoritative" global population forecasts have been declining at the rate of 1 percent each year, and that decline has accelerated in the past five years, as reality undershoots even the declining forecasts, and lower and lower forecasts succeed each other.

Underlying this is the ongoing, sharp plunge in the currently measured, year-to-year growth rate of the world population. In the 1960s and 1970s, it was more than 2 percent per year; in 1987, still at 1.9 percent; by the Rio Conference in 1992, only 1.7 percent; since then, it has plunged to 1.4 percent, according to the 1997 U.N. report cited above. If this trend merely now continues, the annual growth rate will have fallen to 1.2 percent by the year 2000—*almost exactly the 1.1 percent targetted by the NSSM 200* as the lowest possible, "impossible" goal of Malthusian policy.

This is an amazingly drastic decline in a complex annual rate, which *cannot* fall so fast, without war, famine, and disease lowering life expectancies—which are even more important than birth rates, to population growth. And the UNFPA's 1997 Report, for the first time, admits that the sharp drop in population growth is coming not only from sterilization, contraception, and abortion, but also from increasing death rates and sinking life expectancies in a growing number of countries.[3]

At this *increasing* rate of decline of annual population growth, it is evident that, within about 15 years, the world's population will start to decline, never having reached the level of 7 billion human beings, unless there is worldwide economic reconstruction and a reversal of the shrinking of market-baskets of consumption.

On the Edge of Implosion

Already, there is a vast area of the world—including 1.5 billion people, and comprising all of Western, Central, and Eastern Europe, Russia, the other former Soviet Republics, Japan, and the United States and Canada—whose population *as a whole* has stopped growing, and is on the brink of overall decline. This development was analyzed as long ago as 1993 in a special report by *Executive Intelligence Review*.[4]

Within this region—"the North" of the recent decades' geopolitics—nations with falling populations already abound in Europe; especially in Russia and Eastern/Central Europe, where, since 1990, the powerful impact of increasing death rates is manifest. Global speculation and International Monetary Fund conditionalities have utterly devastated the productive economies of these formerly Communist countries, and their health infrastructures. Death rates from disease, social violence, and alcoholism have zoomed upward as birth rates fell, producing a demographic implosion overnight.

This is one of the "singularities," by which a 25-year process of decline in global population growth, intersecting worsening economic collapse, is lurching toward the brink of world population collapse—even as Malthusians have shifted to defining as "overpopulation" the present 5.8 billion level of human beings, or even levels less than half that.

In Brazil, another such "singularity" is clearly threatening to occur. With its cur-

Table 3
U.S. CENSUS BUREAU'S 1987 PROJECTIONS COMPARED TO 1997 POPULATION DATA
(in millions)

	1987 U.S. Census forecast for 2000	1997 Population reported by U.N.	Overestimate
Egypt	71	64	7
Bangladesh	145	122	23
Nigeria	161	118*	43
Morocco	33.3	27.5	5.8
Turkey	68.6	62.8	5.8
Brazil	195	163	32
Mexico	104	94	10
Venezuela	25	22	3
Indonesia	227	203	24
India	1,014	960	54
World	6,300	5,840	460

* U.S. Census Bureau reports 107 million.

rent population 15 percent below that forecast by the U.S. Census Bureau report *only 10 years ago,* its annual growth of 1.2 percent well below the worldwide average, its economic infrastructure being sold off to London banks and speculators like George Soros, and its financial system in crisis, Brazil faces a rapid population implosion.

The Case of Uganda

Another such "singularity," pointing to all of Central Africa, is Uganda. Uganda's President Yoweri Museveni, Britain's designated marcher-lord of the region, has initiated and backed aggressive wars in which perhaps 2 million Africans—Hutus and Tutsis—have died in Rwanda, Burundi, and Zaire *since 1994.* But Uganda itself has become virtually a nation with no hospitals under Museveni's IMF-dictated policies, and it is the epicenter of Africa's AIDS pandemic.

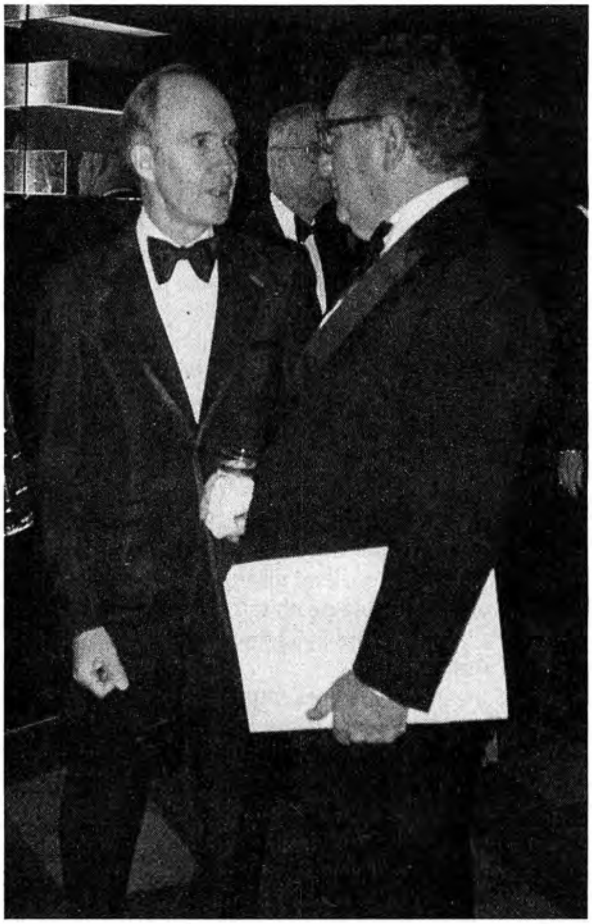
According to the 1987 U.S. Census Bureau report, Uganda's population was then 16 million, and growing at an annual rate of 3.5 percent. The report forecast that Uganda's end-of-the-century population would be 25 million. A decade later, the population is claimed to be 20.8 million, and clearly cannot much exceed 21 million in 2000—15 percent less than predicted a decade ago. Its annual growth rate is now claimed to be 2.6 percent.

But is it 2.6 percent? The average life-expectancy of Uganda's people has dropped to 41.2 years, a drop of 2.4 years since 1994. The country's infant mortality rate has reached nearly 13 percent, as of 1996, compared to 1 percent or less in all economically developed countries. And there has been war raging across the north of the country, continuously, in the 11 years since Museveni took power. There is, in fact, a U.S. Census Bureau regional report, recently prepared, which examines the possibility that by early in the 21st century, the populations of Uganda and several other Central African countries will be declining outright.[5]

Yet, when we consult the UNFPA 1997 report, in the column for population forecasts for the year 2025, we find next to Uganda, a forecast for 45 million people! Thus, a country which grew by 30 percent over the past decade, with a sharply *falling* annual rate of increase, is supposed—by the United Nations—to increase at 40 percent per decade from now until 2025, despite low and dropping life-expectancy, terrible infant mortality, and civil war.

This suggests that the U.N. reports, for Uganda and other African countries, are simply projections on the basis of total fertility rates—in the case of Uganda, the rate is an extraordinarily high 7.1 births per fertile woman—and ignoring or belittling the far more important crises which are ravaging the life-expectancy of those countries.

The population of Uganda has become concentrated in the age groups younger than 20 years old. Does this mean all these youth will have children and swell the population in coming decades? No! It means that as death rates are soaring among those in their 30s and 40s, the productive labor force of the nation is becoming too small, too sick to support all those children and youth. Still less can those youth—if they will die by 40—acquire skills and education, and use them, during their brief productive lives, to help lift the nation out of its horrible crisis. The current shape of Uganda's population pyramid, *given the reasons for it,* will act against, not for, future population growth.



EIRNS

Black-tie depopulators: Sir Brent Scowcroft (left) and Sir Henry Kissinger confer at a 1981 Washington conference. Their efforts, under the aegis of the National Security Council, created a secret U.S. policy of depopulation for the developing sector.

North Korea: Another Devolution

We have to consider the United Nations' current forecast of 30 million people in North Korea in the year 2025, in the same light. North Korea is now gripped by the worst famine anywhere on Earth since World War II. One aid official has estimated that 500,000 to 1,000,000 of the nation's 23 to 24 million people have died of famine this year. No accurate statistics can be gathered as to the total population or the death rate, but it is worsening, world food aid has been completely inadequate, and many aid officials have stated that 5 million North Koreans may die.

What meaning is there to any such forecast as that of the United Nations? We saw in 1980, that U.N. population "data" respecting Cambodia *ignored the entire Pol Pot genocide* which had reduced that nation's population from about 7 million to about 5 million. Today, the United Nations gives Cambodia's population as 11 million—claiming it has more than doubled in 18 years!

In Russia, there is the same fraud in a different form, because Russian national statistical capabilities are relatively accurate. The United Nations' 1997 report does indeed show Russia's population falling, and predicts it will continue to fall. But the United Nations has Russia losing 350,000 people per year; the Russian State Committee on Statistics' latest report shows that the decline is actually running at an annual rate of 500,000 people now. The United Nations is apparently ignoring, or covering up, factors cutting into the population, for those nations with poor data. But, for nations with accurate data, the United Nations cannot conceal those factors, and wishes to minimize them in its forecasts, for consumption by all the zero-growth NGOs.

The case of Nigeria shows clearly that simply inflating population figures is common to the NGOs and international agencies responsible for the "data reporting." NSSM 200 targetted Nigeria among its 13 depopulation targets in 1974, and said then, that the lowest possible population foreseeable for Nigeria in 2000, with drastic measures to reduce fertility in the meantime, was 127 million. The U.S. Census Bureau's 1987 report gave Nigeria's population then, as 108 million, and forecast 161 million in the year 2000.

Now in 1997, the United Nations claims Nigeria has 118 million people—far below all the forecasts—but the Census Bureau acknowledges that the number is only 107 million—a million *less* than it reported for Nigeria 10 years ago! The reason? The Nigerian government's own thorough 1991 census gave the lie to all the international data, which was nearly 20 percent too high. The U.S. Census Bureau admitted this in 1997, but the United Nations still will not.

The Truth of the AIDS Impact

German newspapers, in late September, reported from the press of Kenya, the horrifying forecast of Kenya's Assistant Minister of Public Health that 1 million Kenyans will die of AIDS in the three years to 2000. That means the death of 3.5 percent of Kenya's population. It means annual mortality, *ongoing,* from AIDS of 12 to 13 per 1,000, greater than mortality from all other causes combined. With the IMF having just cut the nation off from all international credit, and Uganda's Museveni trying to invade or foment civil war in Kenya, who can forecast Kenya's demographic future?

There is no evidence that *any* demographic forecast published by the United Nations has ever taken into account the worsening ravages of the AIDS pandemic in developing countries. But in 1994, for the first time, the U.S. Census Bureau published a report of a forecast incorporating the effects of that pandemic, for 16 Third World nations with a total (today) of 433 million people. *The Impact of HIV/AIDS on World Population*[5] covers 13 nations in sub-Saharan Africa, and Brazil, Haiti, and Thailand. All are selected for having 5 percent or more HIV-infection among their "low-risk urban populations," over the whole country.

The demographic devastation of AIDS is not located in its effect on the birth rate, nor primarily upon the infant mortality rate, but on *lifespan,* whose decline stops population growth much more brutally than a decline of fertility. According to this report, "Because of the 7- to 10-year average incubation period between infection and the onset of AIDS, and about a 1-year survival period after the onset of AIDS, deaths from AIDS . . . tend to occur most often in the 30- to 45-year age range. . . . AIDS can increase the mortality rates in these age groups many times over."

This is dramatically illustrated in Figure 11 of that Census report, reproduced here as Figure 1. This shows the huge increase in death rates from ages 20-45, at an overall adult infection level of 20 percent of urban population—a level already reached or exceeded in 6 of the 16 countries. The same report's Figure 14 (here, Figure 2) shows that by 2000, the crude death rate in all 16 nations together will be nearly double what it would be without AIDS, and by 2010, nearly triple.

Most shocking is Figure 18 of that Census Bureau Report (here Figure 3), which shows that by 2010—only 13 years from now—AIDS will have cut the

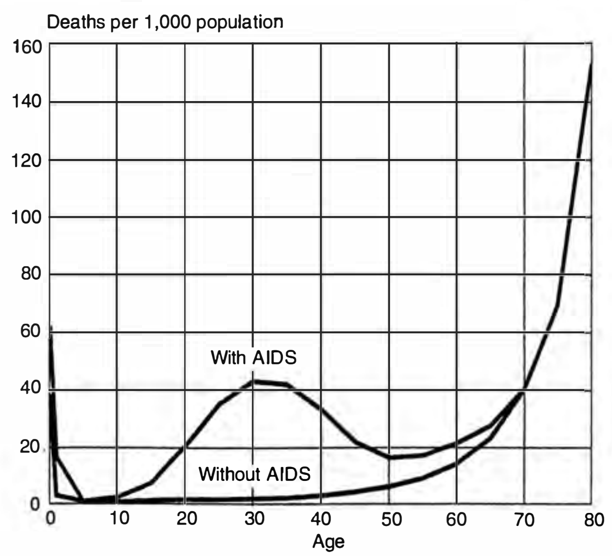


Figure 1
IMPACT OF HIV ON AGE-SPECIFIC MORTALITY RATES AT APPROXIMATELY 20 PERCENT ADULT PREVALENCE

Source: Center for International Research, U.S. Bureau of the Census, *The Impact of HIV/AIDS on World Population* (Figure 11)

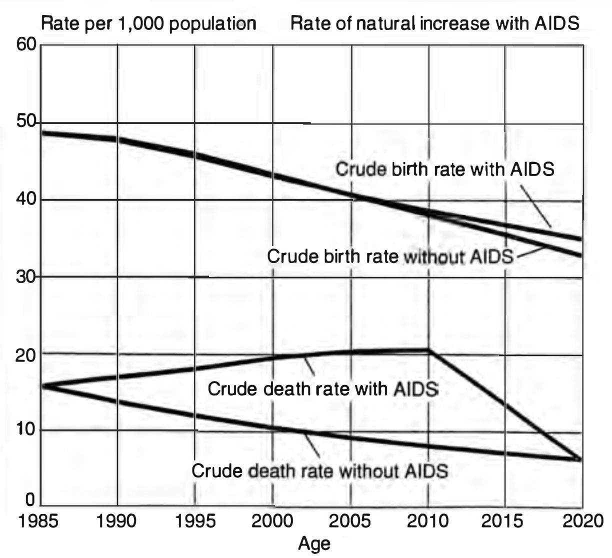


Figure 2
VITAL RATES WITH AND WITHOUT AIDS, FOR 13 AFRICAN COUNTRIES (1985 TO 2020)

Source: Center for International Research, U.S. Bureau of the Census, *The Impact of HIV/AIDS on World Population* (Figure 14) average life expectancy of five of these nations down to the low- to mid-40s, and of eight of the countries, down to the 30s. The authors point out that the higher the life-expectancy had been without the AIDS pandemic, the farther it will fall. By that time it will become impossible—as it is threatening to become in North Korea now—for the decimated productive labor force to support the young and the aged. The population as a whole will collapse, unless this process is overcome and reversed.

Merely a pale, "smoothed out" reflection of this jagged process appears in the matter of comparative forecasts (Table 4). First, the combined populations of these 16 nations for the year 2000 will fall at least 12 percent below what the Census Bureau forecast for them, in 1987, for the year 2000. Second, compared to the United Nations' falsely composed forecast of these nations' populations in the year 2025, this Census Bureau report's corrected forecast for the same year 2025, shows 100 million fewer living souls in those countries. Third, this study was not in any way "corrected" for the ongoing genocide which has spread through Rwanda, Burundi, Zaire, and threatens Kenya, and which the aid agency Oxfam has declared to be producing "the highest mortality rate in human history."

Unless these processes are stopped, and economic reconstruction launched on a worldwide scale under a New Bretton Woods agreement, current population forecasts are meaningless, and the human race faces a global population implosion within the next 15 years.

Table 4
THE AIDS PANDEMIC IN POPULATION FORECASTS FOR THE YEAR 2025
(in millions)

	U.N. 2025 forecast ignoring AIDS	U.S. Census forecast with AIDS
Burkina Faso	23.5	16.0
Burundi	12.3	11.0
Central African Republic	6.0	4.0
Congo	5.7	3.1
Ivory Coast	24.4	29.1
Kenya	50.2	42.8
Malawi	20.4	15.0
Rwanda	13.0	13.2
Tanzania	62.4	44.1
Uganda	45.0	33.8
Congo-Zaire	105.9	91.9
Zambia	16.2	15.2
Zimbabwe	19.3	13.0
Brazil	217.0	198.0
Haiti	12.5	9.8
Thailand	69.1	63.0
TOTAL	**702.9**	**603.0**

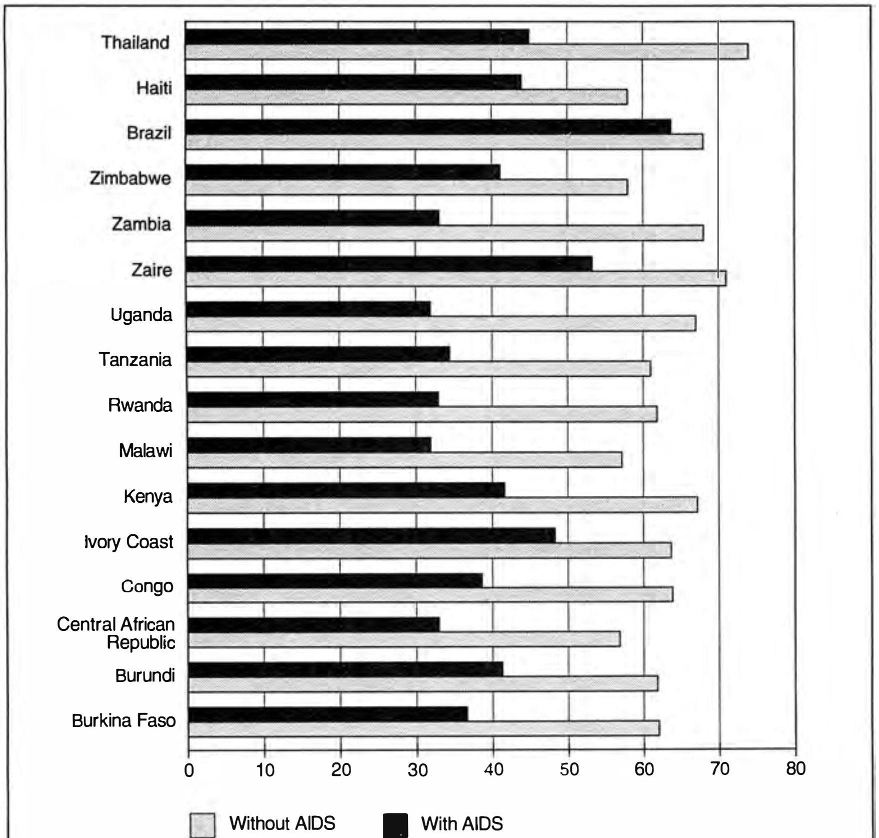


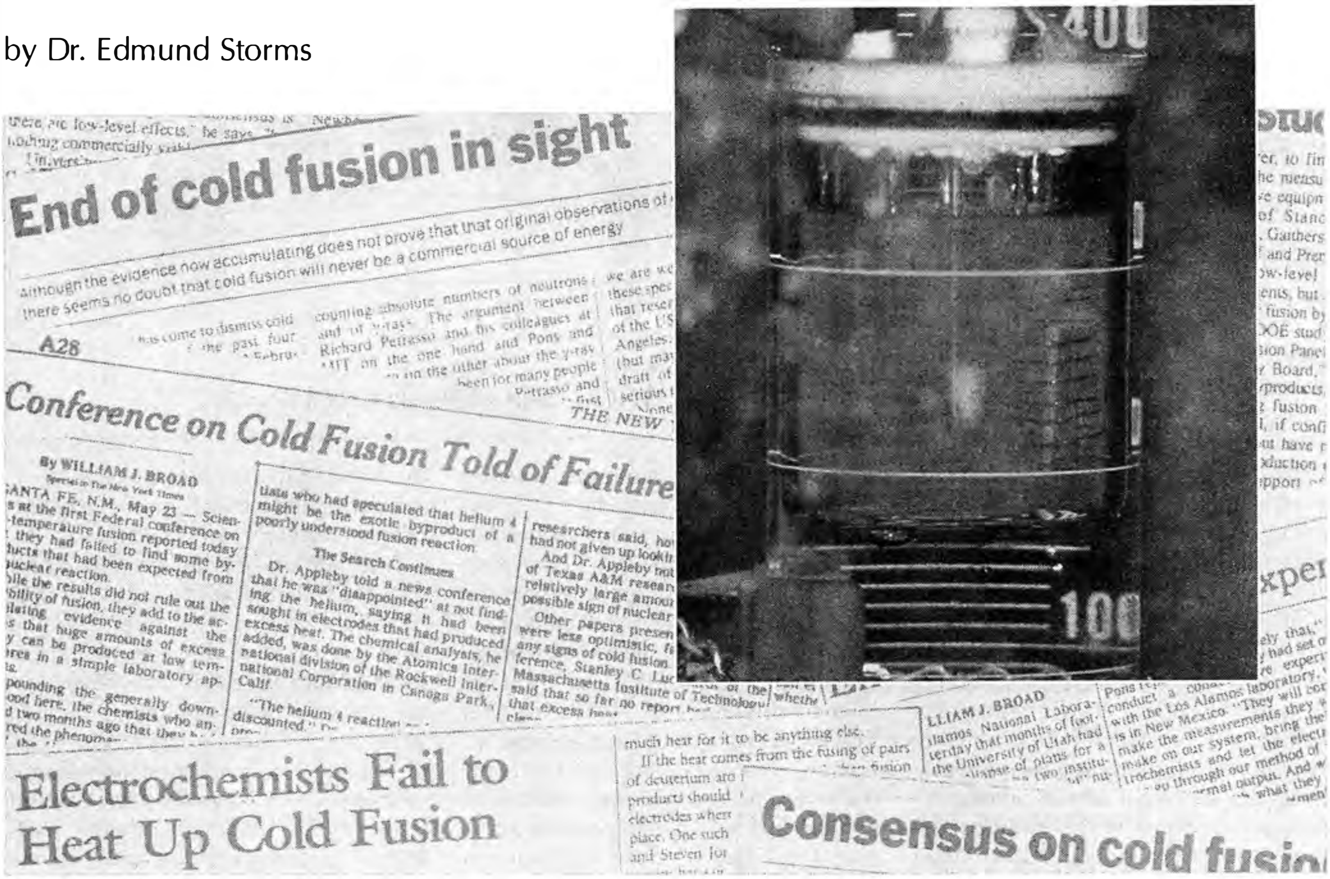
Figure 3
LIFE EXPECTANCY AT BIRTH WITH AND WITHOUT AIDS IN 2010

Notes

1. Lyndon H. LaRouche, Jr., 1991. *The Science of Christian Economy and Other Prison Writings* (Washington, D.C.: Schiller Institute), and his text in mathematical economics, *So, You Wish to Learn All About Economics?* (2nd edition, Washington, D.C.: EIR News Service, 1995).
2. The complete NSSM 200 and all of its supporting documents were reproduced in a 1996 book, *The Life and Death of NSSM 200*, by the radical Malthusian Steven Mumford. For 25 years, Mumford has supported all means of population control and reduction, eagerly studying war in Central America in that connection, for example. His book's contention, that nothing of NSSM 200 was ever implemented, is patent fraud, as this article demonstrates. Mumford's other obsessions, that Pope John Paul II rules the world, and that Catholic faith and U.S. citizenship are incompatible, are sad examples of the danger of extreme politicization of religious "differences." Mumford is a contributing editor of *The Churchman*, the Church of England's public affairs magazine.
3. See Gabriele Liebig, "The Orchestrated Population Implosion," *The New Federalist*, Sept. 1, 1997.
4. Mary Burdman, "The Coming Depopulation Bomb," *Executive Intelligence Review*, July 2, 1993.
5. U.S. Bureau of the Census, *The Impact of HIV/AIDS on World Population*, May 1994. Developed by State Department-Commerce Department Interagency Working Group on AIDS models and methods.

Cold Fusion: An Outcast of Science

by Dr. Edmund Storms



Science, we are taught, is a search for truth. Increasingly, in the United States, this idealist notion is becoming even less true. Many examples of this deterioration are available, but none is more extreme than the present attitude toward the discovery conventionally called "cold fusion."

Eight years ago, two otherwise conventional scientists proposed that nuclear reactions could be initiated in palladium containing a high concentration of deuterium. Profs. Stanley Pons and Martin Fleischmann went on to demonstrate the production of energy by what they proposed to be a fusion reaction between two deuterium nuclei.[1] When this claim proved to be very difficult to duplicate, and impossible to explain using conventional models, most scientists rejected the claim. Since then, this rejection has become so clothed in emotion that various influential scientists have actively worked to prevent information about the phenomenon from being published, have discouraged scientists from working on the problem, and have presented false and distorted information to the media and to their colleagues.

Why would otherwise honest and fair-minded members of the scientific community go to such extreme lengths to stop the development of a proposed discovery about nature?

The answer involves three factors: the unconventional nature of the scientific claims, the manner in which the original claims were made public, and the tendency of the media to distort a situation to their own benefit. Of course, if the skeptics are right and the claims are actually nonsense, then all of these issues become irrelevant. So, I will start by examining each issue, starting with a demonstration that some of the claims are real, or at least real enough to warrant further examination.

The cold fusion claims involve the production of anomalous energy far in excess of any conventional chemical source, production of elements not present in the original environment, and production of radiation that can only result from a nuclear reaction. Each of these claims is found to occur in a variety of materials using a variety of techniques, and when deuterium, as well as normal hydrogen, are present.

The nuclear products are: helium and tritium; atoms that appear to result from fusion of various heavy nuclei with the particular hydrogen isotope that is present; and atoms that appear to result from the fission of various heavy nuclei, such as palladium, into smaller atoms. Radiation in the form of neutrons, gamma rays, X-rays and charged particles has been detected, all at very low levels. This collection of phenomena, suggesting the creation of nuclear reactions in a chemical environment, would seem to be enough to excite even the most unimaginative person. Rather than calling the effect "cold fusion" a better name might be chemically assisted nuclear reactions (CANR).

Although more than 50 examples of excess heat production can be cited, including one using an exact replication of the Pons-Fleischmann cell,[2] I do not have space here to do all of them justice. However, one extensive study done at Stanford Research International, or SRI, stands out for its completeness and its use of state-of-the-art equipment.[3] The Electric Power Research Institute (EPRI) invested more than $6 million to give us this information. IMRA (Japan) has continued to support the work for the last three years after EPRI had withdrawn from the field.

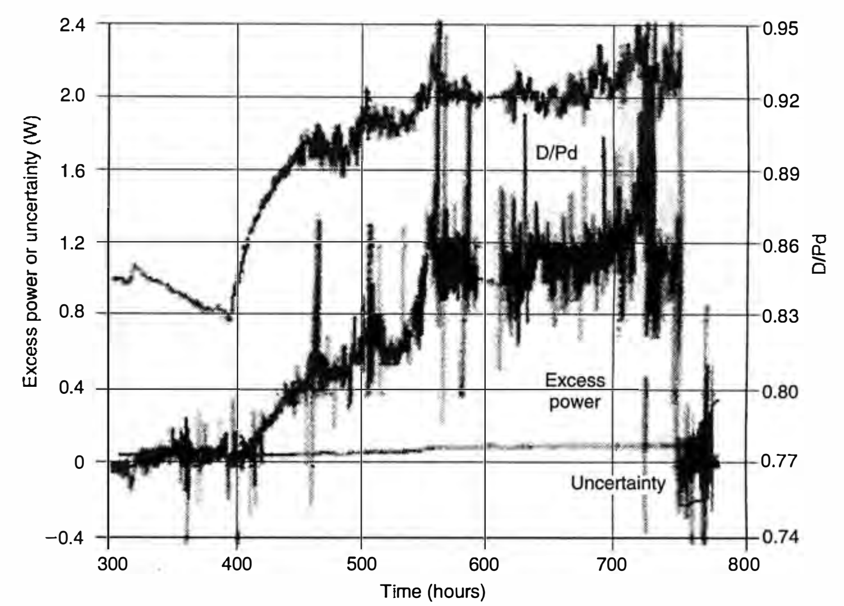


Figure 1
TYPICAL DATA FROM SRI CALORIMETER

The SRI Experiment

In the SRI experiment, a flow calorimeter is used in which flowing water captures power produced within an electrolytic cell containing a heavy-water electrolyte and a palladium cathode. Although power production can be measured by knowing only the flow rate of water and its temperature change, the calorimeter was occasionally calibrated by applying power to an electric heater or by the electrolytic process. A catalyst was present within the cell, so that any O_2 or D_2 was recombined back to D_2O. The absolute accuracy was shown to be ±50 milliwatts, with an even better stability. Nineteen samples of palladium produced anomalous energy. Typical data are shown in Figure 1. This sample showed no excess heat until after the current had been increased at 400 hours.

In addition, the study shows that certain impurities within the electrolyte would improve the odds, that a critical average D/Pd ratio is required, and that certain batches of palladium are more active than others. This and other studies are consistent in demonstrating that the nature of the palladium, including the surface impurities, determines whether excess energy can be produced. Unfortunately, palladium is notoriously inhomogeneous and difficult to obtain with known, fixed impurities, at least at the levels important to this phenomenon.

On the other hand, Clean Energy Technology Inc. (CETI)[4] and E-Quest[5] have technologies for generating heat that are reproducible, and are now attracting commercial interest. CETI produces heat using a light-water electrolyte combined with a complex nickel cathode, and E-Quest loads palladium and other metals with deuterium using ultrasonic cavitation of D_2O. Both methods continue to show evidence for a variety of nuclear reactions.

Nuclear Products

Tritium is a radioactive isotope of hydrogen that can only be produced by a nuclear reaction. Dozens of claims for its production in a chemical environment have been published. All have been rejected by skeptics who argue that the tritium was initially present in the palladium. This attitude prompted several studies of commercial palladium.[6] All found no evidence for tritium contamination. Dr. Tom Claytor, working at Los Alamos National Laboratory (LANL), has done a very complete job of eliminating all sources of tritium contamination.[7] Nevertheless, he is occasionally able to produce tritium in a low-voltage electric discharge in deuterium gas, using a palladium cathode. Here again, the nature of the palladium is important for success.

One of the major nuclear products associated with energy production in D_2O is helium. Skeptics have rejected the work because they believe the helium resulted from air leaked into the apparatus, there being about 6 ppm of helium in air. Recent studies have eliminated this argument by measuring the presence of argon, which also would have arrived with the air. There are now six studies,[8,9,10,11] several still unpublished, reporting helium.

Several of these helium measurements are nearly consistent with the measured excess energy based on a D-D fusion reaction, one of which is shown in Figure 2. Dr. Yoshiaka Arata at Osaka University in Japan was the first to see He-3 along with the normal He-4. Although this lighter isotope is more difficult to isolate from the other species in a mass spectrum, its presence adds great weight to the claim for an unusual nuclear reaction.

Increasingly, claims are being made for nuclear reactions based on fission of one or more of the metal atoms in the electrolytic cell. This so called transmutation reaction is being proposed as a potential method to make radioactive isotopes quickly nonradioactive. Prof. George Miley (University of Illinois)[12]

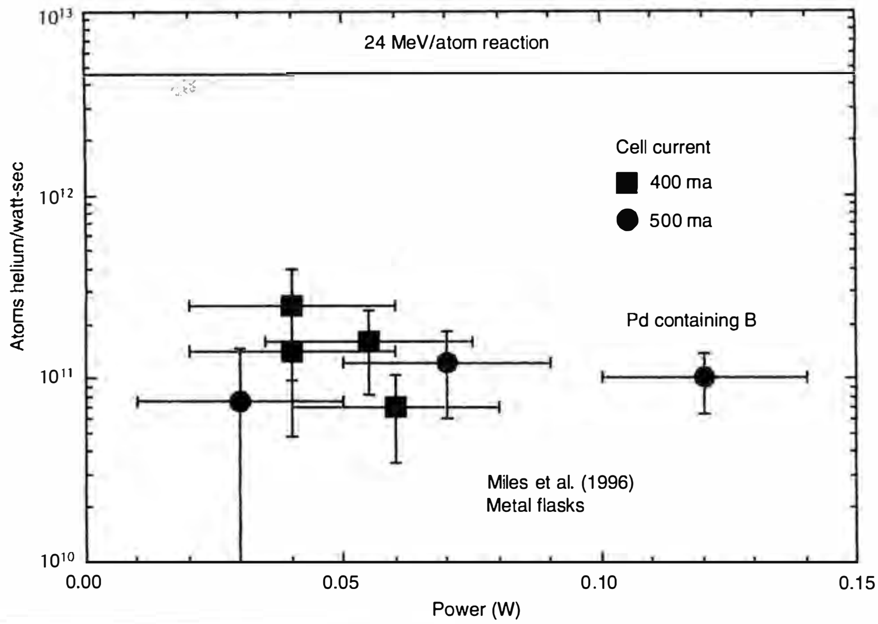


Figure 2
HELIUM PRODUCTION COMPARED TO HEAT PRODUCED IN A PONS-FLEISCHMANN TYPE CELL
Helium production detected in the surrounding gas is compared to heat produced in a Pons-Fleischmann type electrolyte cell.

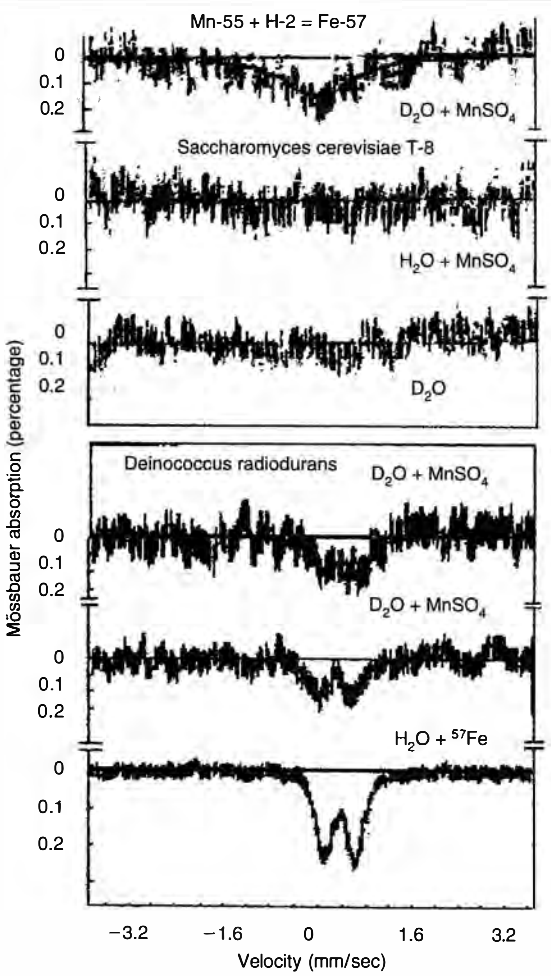


Figure 3
MÖSSBAUER ANALYSIS OF Fe-57

has been exploring these reactions using a cell similar to the CETI design. Dr. Tadahiko Mizuno of Hokkaido University in Japan[13] sees evidence for transmutation in a cell based on proton conduction through a semiconductor. An increasing number of other scientists have also seen evidence for the effect. A laboratory calling itself "The Cincinnati Group"[14] has claimed to be able to transmute large quantities of thorium and other radioactive materials to nonradioactive products. The early, impressive results have encouraged the group to sell kits to persons wishing to demonstrate the effect for themselves.

Although much of this work is still unpublished, the claims are being supported with increased sophistication and consistency.

Biologically Induced Nuclear Reactions

Living systems have been claimed in the past to initiate nuclear reactions when needed elements were absent in their diets.[15] Only recently has this belief been put to a test, using modern analytical techniques. Prof. H. Komaki in Japan has examined various yeasts and bacteria cultures for their ability to manufacture elements needed for growth from other atoms present in the cultures.[16] Evidence for the production of calcium, potassium, magnesium, and manganese is given.

A particularly compelling demonstration was recently done in Russia.[17] This work clearly demonstrates fusion between Mn-55 (manganese) and deuterium to give Fe-57 (iron) in various yeast and bacteria cultures. In this case, the Mössbauer effect was used to determine the quantity of Fe-57 produced using a Co-57 (cobalt) gamma emitter. The relative velocity between the emitter and the absorber, shown on the *x*-axis in Figure 3, was varied until the gamma energy matched that required for absorption by the Fe-57 nucleus. The Fe-57 is produced only when manganese and deuterium are both present in the culture and at a rate of $(1.9 \pm 0.5) \times 10^{-8}$ Fe-57 per second per Mn-55.

The bacteria culture, shown as the lower part of Figure 3, produces a double hump in the spectra as did pure Fe-57 when it was added to the culture. This behavior shows that Fe-57 made by a nuclear reaction, and Fe-57 added to the culture, both occupy the same chemical environment. However, this environment is different from the one in the yeast culture shown in the upper part of Figure 3. It is important to realize that this study uses conventional, well understood methods that are only sensitive to the presence of Fe-57 and cannot give a false positive result. Therefore, it is hard to avoid believing that a nuclear reaction can occur in a biological system. Of course, many readers may successfully avoid this belief.

Why is it so impossible for many people to accept these ideas? The many failed attempts to replicate the claims, especially those at several high-profile institutions, give the impression that the phenomenon cannot be reproduced at will, and hence is not real. Indeed, at one time this was the correct conclusion. As the variables have been better understood, however, success rates have improved. Certain methods and results are now highly reproducible in the hands of skilled experimenters.

Controlling the Variables

Nevertheless, some methods continue to give unpredictable results and some reports of success are probably still caused by error. Many negative results are now known to be caused by a failure to understand and control important variables.[18] For example, we now know that a nuclear effect will not occur in an electrolytic cell using a palladium cathode when too much light water (H_2O) is present in the heavy water (D_2O). Most early studies showing negative results used open cells which readily absorbed H_2O from the atmosphere.

Of course, random error can still play a role, but a growing understanding indicates that this is not the main cause of positive results. Nor is a failure to consider the Faraday efficiency in open cells a major source of calorimetry error in most studies, as argued by Jones et al.,[19] because most recent work uses closed cells or measures the recombination rate.

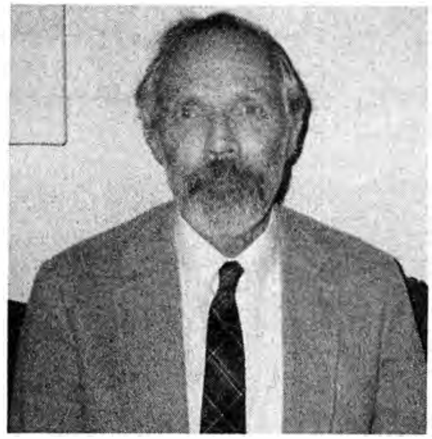
When a fusion reaction is produced at high temperatures in a gas plasma, in the Tokamak, for example, neutrons and tritium are produced in equal amounts and at high levels. In contrast, the CANR reaction does not generate these products in the ratio or quantities expected, based on the "hot fusion" behavior. Indeed, anomalous heat is seldom associated with tritium production, and very few neutrons are detected. When tritium is produced, the neutron/tritium ratio is less than 10^{-6} and 14 MeV neutrons produced by the expected T + D fusion are absent. The only products associated with energy production involving deuterium are helium-4 (He-4) and weak electromagnetic radiation. These contrasting observations are summarized in Table 1.

Fusion production of He-4 in a gas plasma is always accompanied by 24-MeV gamma emission. Absence of this radiation is a major reason why many people reject the CANR claim. They fail to consider at least five other reactions that result in helium without accompanying gamma radiation, as listed in Table 2. Each of these suggestions has a theoretical basis and, in a few cases, some experimental support. Therefore, we can not reject helium production just because gamma radiation is not seen. We should instead give thanks!

Well-established theory predicts that the coulomb barrier cannot be overcome using such small energies as are present in a chemical structure. Clearly, if CANR is to occur at all, a mechanism must exist that does not require high energy, that does not catalyze the usual fusion paths, and that is able to absorb the resulting nuclear energy without producing significant radiation. This is a lot to ask of any process.

To make matters worse, energy production from light hydrogen and the newly discovered transmutation reactions introduce a whole new set of problems that tax any explanation. We can either accept the conventional viewpoint and throw out all experimental observations involving CANR, or we can search for new theories that consider the novel characteristics of the chemical environment without throwing anything away. In other words, the results obtained at high energy are correct for the environment in which they were obtained, and the CANR results are also correct for their environment.

Most of the new explanations take this approach. There is no lack of possibilities. (A few will be discussed below.)



Edmund Storms: "What can be said of the health of science, when major scientists and scientific societies reject a phenomenon without an honest examination of the evidence?"

Table 1
THE NATURE OF THE FUSION REACTION

	Hot Fusion D + D	Cold Fusion >2 KeV <1 eV
→ T(1.0 MeV) + p(3.05 MeV)	(50%)	(<0.1%)
→ ^{3}He(0.82 MeV) + n(2.45 MeV)	(50%)	($\leqslant 10^{-6}$%)
→ ^{4}He + γ(24 MeV)	($<10^{-3}$%)	(≈100%)

D + T → ^{4}He + n(14MeV)

"Readers might well ask why the truth is so badly distorted by the media." Here, Martin Fleischmann (left) with Stanley Pons and Steven Jones at a 1989 news conference sponsored by the Electrochemical Society in Los Angeles.

The challenge is to demonstrate which one is correct.

The Basis for Skepticism

The present situation cannot be understood or changed without acknowledging the strong psychological basis for skepticism. Profs. Pons and Fleischmann were two chemists who entered the very select world of nuclear physics through the back door. To make matters worse, they announced their discovery through the media, rather than using peer-reviewed scientific journals; they exaggerated the ease of duplicating the effect; and they made at least one technical mistake.

Further, their claims, if true, would undermine a major research industry which has tried to produce commercial fusion power for the last 40 years, all at great expense and with limited success. Other energy-based industries would also suffer. Scientists would be required to change or abandon much of their hard-won understanding of nuclear interaction, an understanding that appears to be very solid. The government cannot now admit that the effect is real without seriously embarrassing the Department of Energy, the Patent Office, and many senior scientists.

Well over a hundred explanations of CANR have been attempted, most having little relationship to utility or even reality. Such a novel field, where normal rules do not seem to apply, attracts many people who prefer to live in their own world. However, several models do seem to offer important, partial insights into possible processes. Many of these models have continued to be changed and improved over the years. Unfortunately, most theories address the nuclear process while ignoring the unique environment in which such reactions must occur. In addition, most models still conflict with some aspect of experimental observation or rest on assumptions not supported by observation.

Because the nuclear events occur in a variable number of random sites within the bulk material, a quantitative relationship between theory and observation is not yet possible, even though many attempts have been made. No theory has explained why only these rare sites are active or has predicted their chemical characteristics, except in the most general terms. A few examples are summarized below to provide a partial insight into the approaches being explored. It is still very risky, and likely to raise the emotional level in some quarters, to suggest which of these approaches might be right or wrong. Therefore, neither the choice of examples nor their sequence represent a judgment of value. A courageous analysis of several theories has been provided by V. Chechin.[20]

A Review of Theoretical Models

Scott and Talbot Chubb (Oakton International Corp., Arlington, Va.).[21] This model uses ion band state theory involving stationary, three-dimensional Bloch states to explain the fusion process. Thus, the deuterium nucleus is thought to act as a wave, without exhibiting a charge barrier. Fusion occurs through D+-D+ wave overlap when the deuterium concentration has achieved a critical value, and when other conditions are present. The theory predicts that a critical crystal size is required, and that He-4 is the nuclear product, without gamma radiation being emitted. Energy is coupled to the lattice by a coherent process involving transfer of electrons to higher energy states.

Giuliano Preparata (INFN, Italy).[22] Using Quantum Electrodynamics (QED), this model proposes that various coherent plasma fields exist in a crystal structure; that is, the fields act like electron lasers which are completely contained within the structure. These fields are proposed to combine and provide sufficient coulomb-barrier screening of deuterium nuclei to allow fusion and other reactions to take place.

The model requires that the fusion process occurs at tetrahedral sites when the deuterium concentration has reached very high values. Released energy is absorbed by the coherent fields, which then emit X-rays.

Yu. Bazhutov (Erzion Center, Moscow, Russia).[23] Small quantities of massive, stable hadrons are thought to be present in all matter. Under certain conditions, these particles can be released from their bound state and catalyze nuclear reactions. Joseph McKibben (Los Alamos National Laboratory),[24] has taken a similar approach by proposing the presence of fractionally charged particles. These particles can stabilize unusual nuclei, which act chemically like normal matter and, when destabilized, can produce energy and catalyze various nuclear reactions.

X.Z. Li (Tsinghua University, China).[25] A very narrow energy level is proposed to exist in the nucleus. This level is able to resonate with certain energy levels in the surrounding atomic lattice. This process is proposed to promote coulomb-barrier penetration and nuclear interaction.

Peter Hagelstein (Massachusetts Institute of Technology).[26] Hagelstein has replaced his virtual-neutron model by one involving energy transfer from a phonon laser, or strong resonance vibrations operating within the lattice. In other words, vibrations of individual atoms caused by their temperature combine to produce pockets of higher energy (temperature). Energy is accumulated in the phonon bands by nonlinear frequency shifting involving fluctuations in the phonon spectrum. This enhanced energy is transferred to a few atoms by the usual vibrational processes causing adjacent nuclei to approach each other with sufficient energy to cause various nuclear interactions, including fusion and transmutation.

The "lattice quake" model of Arata[27] has similar features leading to fusion. Yan Kucherov (ENECO)[28] has employed phonons to accumulate energy directly in the energy levels of various metal nuclei, which is then released by alpha emission or fission.

Randell Mills (Blacklight Power).[29] All isotopes of hydrogen are proposed to have fractional energy levels below those described by conventional quantum theory. Electrons can be caused to access these levels if a suitable repository for the released energy is available. Consequently, under certain conditions, energy can be released by the formation of collapsed hydrogen atoms called hydrinos. These smaller hydrogen atoms leave the system and return to their initial size and energy elsewhere in the world. Therefore, this is an energy transfer process which does not involve nuclear reactions.

However, tritium can sometimes result when complete atom collapse produces a neutron which reacts with a nearby deuterium nucleus. Variations on this approach have been proposed by Jacques Dufour (Shell, France)[30] and Yi-Fang and Zheng-Rong (Yannan University, China)

Hideo Kozima (Shizuoka University, Japan).[31] Thermal neutrons are proposed to be trapped in crystals where they can, under the proper circumstances, interact with nuclei. This is called the TNCF model (trapped neutron catalyzed fusion). The neutrons are thought to be stabilized by forming neutron Cooper pairs and by acting as Block waves, which prevent normal neutron decay and prevent interaction with nearby nuclei until the crystal suffers a large perturbation. This perturbation is proposed to be caused by certain surface impurities, some of which subsequently react with the released neutrons.

Y.E. Kim (Purdue University).[32] This is not a general model, but a more exact calculation of the magnitude for the coulomb barrier, using conventional methods. The analysis concludes that barrier penetration for fusion is easier than first thought, but not as easy as is required to explain many CANR claims.

Many of the models propose resonance processes, but they differ in what is resonating, and how the resonance structure interacts with the nucleus. The Chubbs visualize direct interaction of deuterium waves; Preparata sees a wave-like electron structure that neutralizes the coulomb barrier; Kucherov and Li would have vibrational energy of the atom-electron structure add energy directly to the nucleus, thereby causing destabilization; and Hagelstein and Arata have this vibrational energy cause direct nuclear interaction between adjacent nuclei. Each model has the resonating structure carry away the resulting nuclear energy, which is dissipated throughout the lattice as heat and X-rays.

The models proposed by Mills and Dufour, involving a change in energy and size of the hydrogen atom, are not part of CANR, unless this change results in a nuclear reaction. Although most examples of heat production are not consistent with this model, occasionally results are seen which are consistent. Perhaps several mechanisms are possible, depending on the imposed conditions.

Media Distortions

Last but not least, the role of the media needs to be examined. To do this, we consider two of the most recent statements about the field, the television program "Junk Science," aired twice on ABC,[33] and *The New York Times* article about the closing of the New Hydrogen Energy laboratory in Japan.[34]

In "Junk Science," reporter John Stossel portrayed Pons and Fleischmann as two men so consumed by the need for fame, that they were deceived by their false results. The truth is very different. In fact, these scientists did not want to reveal their work at all, because they knew much more justification was required. To obtain money for further work, they sought funds from the U.S. Department of Energy. This process alerted Prof. Steven Jones at Brigham Young University to their work, and started the sad chain of events as described accurately in several books.[35,36]

It was the president of the University of Utah who forced a news conference, over strong objections, in order to attract fame to the University of Utah rather than to Brigham Young University—an event that forced premature publica-

Table 2
POSSIBLE REACTIONS PRODUCING HELIUM BUT NOT GAMMA EMISSION

1. Multiple fusion to produce helium
   $D + D + D \rightarrow {}^4He + D$
   $D + D + D + D \rightarrow 2\,{}^4He$
2. Reaction with boron impurity to produce helium
   $D + {}^{10}B \rightarrow {}^4He + {}^8Be$
   ${}^8Be \rightarrow 2\,{}^4He$
3. Reaction with lithium impurity to produce helium
   $D + {}^6Li \rightarrow {}^8Be \rightarrow 2\,{}^4He$
4. Fusion with a metal leading to alpha decay
   $D + {}^nM \rightarrow \alpha + {}^{(n-2)}M$
5. Collapse of deuterium atom to produce beta decay and helium
   $D + e^- \rightarrow 2n$
   $2n + D \rightarrow {}^4H \rightarrow {}^4He + e^-$

tion. Once the claims became known to the scientific and political world, the potentially important implications caused massive attention by scientists and by the press, a completely normal and expected reaction, which short-circuited the normal peer-review process.

A more recent distortion appeared in *The New York Times,* which gave the impression, in the cited article, that the New Hydrogen Energy government laboratory was closed because the Japanese lost interest in CANR. In fact, the laboratory was scheduled years ago to close on March 31, 1998, after having received a one-year extension. After that date, industry is expected to carry on the work. Unfortunately, the NHE laboratory has not been able to demonstrate excess energy production, although various nuclear products have been detected. Other laboratories in Japan have been more fortunate, and are continuing to explore the phenomenon.

Readers might well ask why the truth is so badly distorted by the media.

Questions for the Reader

After considering this brief summary of evidence, you, the reader, should next examine the implications of this phenomenon, and the consequences of its treatment by the scientific establishment, the media, and the government. Why are scientists in many major countries given support to study the phenomenon, but not in the United States? What will happen to the transportation and manufacturing industries in those countries not having ready access to this source of clean and cheap energy?

And what can be said of the health of science, when major scientists and scientific societies reject a phenomenon without an honest examination of the evidence? Is it possible that life itself shapes the nuclear landscape, and that given the right conditions, the job can be done with great efficiency?

There are no end of examples where new and correct ideas are rejected by conventional science.[37] Each generation thinks that objectivity has improved, only to be disappointed by the reactions to another discovery. Aside from the nature of some people to fight change, a double standard is applied by skeptics. They insist that all new claims must be proven to their satisfactions; at the same time, the skeptics assume no responsibility in this process.

Thus, the cliché that extraordinary claims require extraordinary proof is often heard. Overlooked is the fact that disbelief is as frequently wrong as is belief. Therefore, a search for reality requires cooperation between both viewpoints. A better statement would be that extraordinary claims require an extraordinary effort by everyone to find the truth. This joint effort needs to be applied to CANR.

For those of you who would like to explore this phenomenon, an extensive review of the field is published in the *Journal of Scientific Exploration,*[38] and a bibliography can be obtained from Dieter Britz[39] or Hal Fox.[40]

Edmund Storms retired in October 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 systems.

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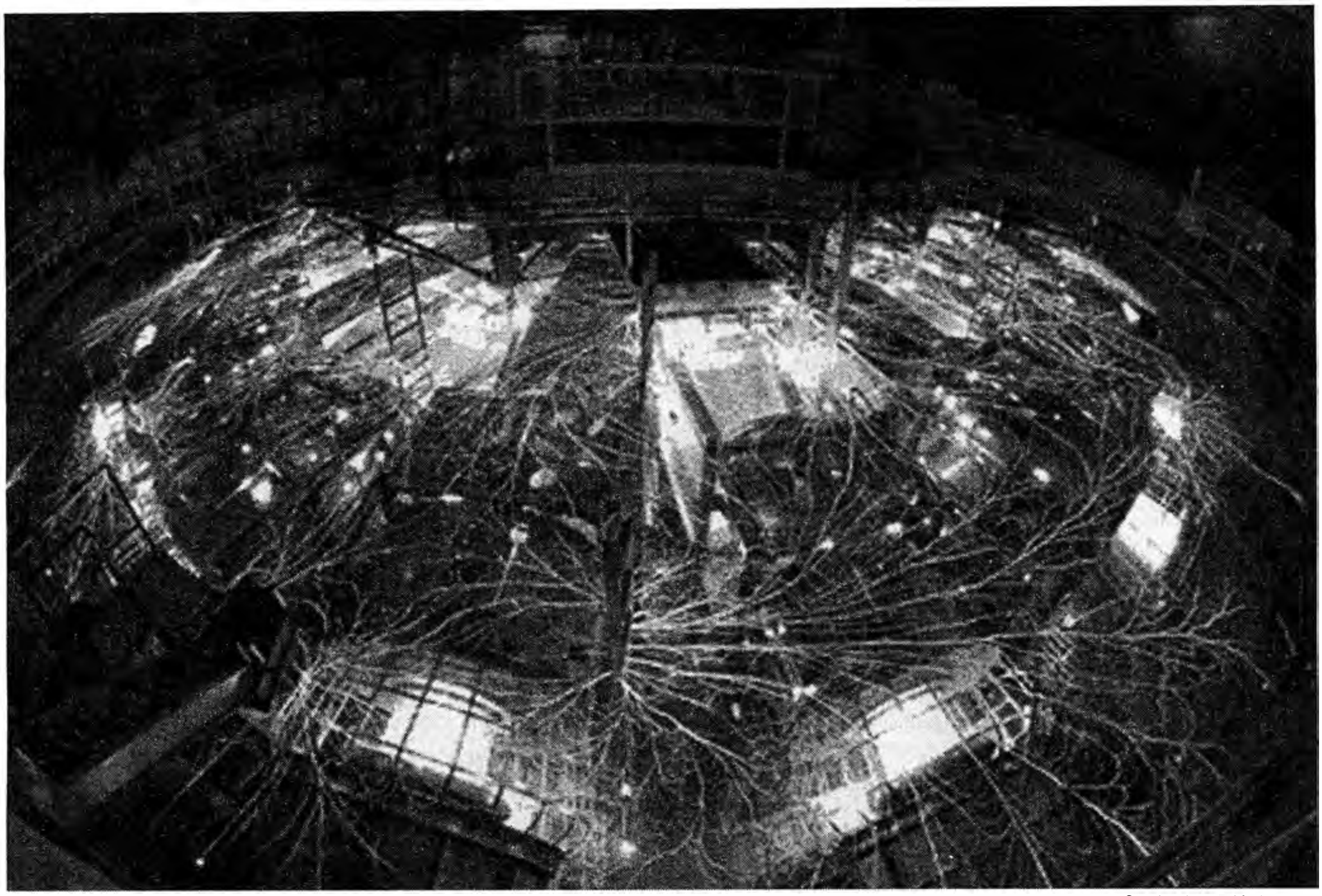
Sandia National Lab Clears Path to Inertial Fusion

by Charles B. Stevens



Sandia National Laboratory

Electrical discharges illuminate the surface of the Z machine, the world's most powerful X-ray source, during a recent accelerator shot. In July, the Sandia accelerator achieved temperatures of 1.5 million degrees, close to the 2 to 3 million degrees required for driving nuclear fusion. In the last 10 months, breakthroughs have enabled the machine to more than quintuple its output.

In July 1997, scientists working at the Sandia National Laboratory in Albuquerque, New Mexico, demonstrated that the Z accelerator is a pulsed power technology capable of igniting thermonuclear fusion and releasing the virtually unlimited potential of this energy source which powers the Sun and the other stars. The key to this success was the use of a z-pinch as the driver of the Sandia pulsed power technology, which has been under development for more than four decades. This general idea had originally been proposed by the great Russian scientist Andrei Sakharov in the 1940s, and more recently by the late Winston Bostick, a founder of the Fusion Energy Foundation and a pioneer of fusion research, and of the plasma pinch, in particular.

Bostick's proposal was made in early April 1983, when the author and Professor Bostick were talking to scientists about the LaRouche-designed Strategic Defense Initiative, announced by President Reagan on March 23, 1983. Instead of pursuing the generation of various types of particle beams, both ion and electron beams, for driving the implosion of inertial confinement fusion pellets, the idea was to deliver the Sandia pulsed power to a plasma z-pinch, and let the plasma process itself (explained more fully below) generate an energy densification sufficient to ignite fusion directly, or to drive an inertial confinement fusion pellet to fusion ignition conditions.

After more than 10 years, this is what Sandia is now doing.

What Is Inertial Confinement?

Nuclear fusion of hydrogen nuclei to form helium is the source for the energy output of the stars. There is enough deuterium (heavy hydrogen)—which is fusion fuel—in a gallon of seawater to generate the energy equivalent of 300 gallons of gasoline. The heavy hydrogen is only a minute part of the gallon of water, and costs a few cents to extract. Therefore, fusion energy offers a potentially cheap, clean, and virtually unlimited source of energy.

Inertial confinement fusion was first demonstrated in the early 1950s, when both the United States and the Soviet Union successfully detonated the hydrogen bomb. In that case, an atom bomb was used to generate a burst of X-rays. These X-rays then impinge on a target made of fusion fuel. The incident X-rays burn off a thin surface layer of the target, generating a very hot plasma exhaust. Like a rocket, this exhaust drives the remaining portion of the target inward. This implosion process compresses the fuel, and, at the final stages of the process, the implosion develops a shock wave, which heats the compressed center of the target.

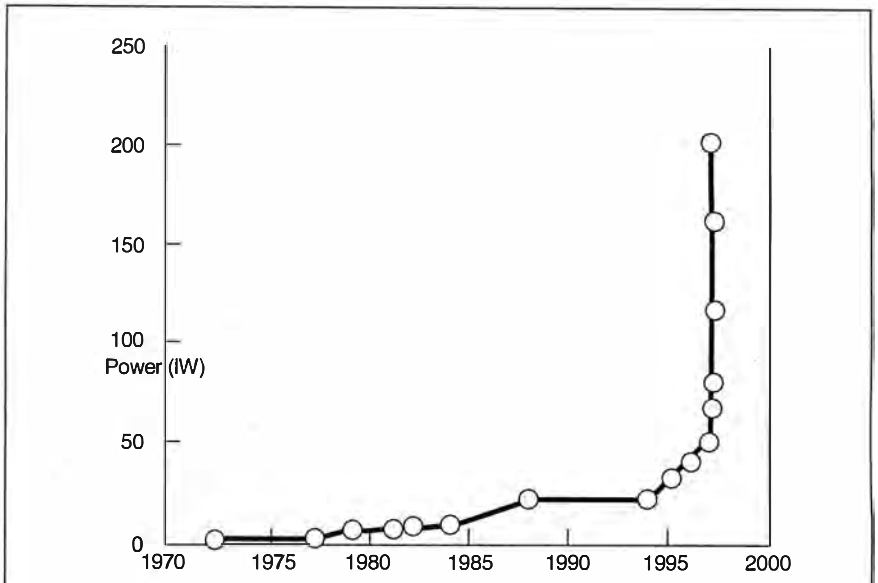
In this way, the temperatures of hundreds of millions of degrees, and the very high densities required for sparking thermonuclear fusion, are generated in inertial confinement fusion. Only the central part of the target is heated by the implosion process. The remaining fuel is heated by the output of the fusion energy from this central region.

Overall, the inertial confinement fusion process can be described as a series of stages of amplification and tuning of energy to generate the required conditions for fusion. In the hydrogen bomb, chemical explosives implode fission fuel to produced a critical mass, which generates the chain reaction and explosion. The fission explosion is hundreds of times more intense than the chemical one. But the fission fireball is still about 99 percent as intense as that required for igniting fusion. The implosion process and resulting thermonuclear burn wave amplify the intensity by about a factor of 100 to the required level.

High-energy lasers and pulsed power sources, such as the Sandia Z accelerator, provide an even more intense driver for inertial confinement fusion implosions than atomic bombs. Because of this, the resulting scale of the fusion explosion is only one millionth that of the hydrogen bomb.

How to Cook Turkeys—and Critics

In many respects, the technology Sandia used to achieve the energy densities



Z ACCELERATOR POWER OUTPUT ZOOMS UP

After many years of modest increases, Sandia researchers achieved a sharp upward rise in the power output of the Z (formerly PBFA-Z) accelerator, during the first half of 1997. The advance coincides with the introduction of a new configuration for a cylindrical array of wires that becomes an imploding plasma. The Z accelerator is the latest in a succession of X-ray-generating devices at Sandia, most recently the Saturn.

required to drive inertial fusion pellets can be traced back to the work of Benjamin Franklin. Franklin was often criticized for pursuing his "ethereal" studies of electricity, which were alleged to have no practical application. So, Franklin held a barbecue for his critics in which he discharged a large number of Leyden jars into wire-skewered turkeys. The turkeys were well cooked—even a bit burned—by this method, and Franklin's critics given their just desserts.

The irony is that scientists at Sandia, working in collaboration with Russian scientists, have now demonstrated that the Franklin approach is not only good for roasting turkeys and critics—but also for cooking up thermonuclear fusion!

This work also has bearing on the controversy between the prevailing Maxwellian theory of electromagnetism and the alternative electrodynamics of Ampère, Gauss, Weber, and Riemann, as noted below.

Sandia's Achievement

Sandia demonstrated in July that the Z accelerator is a technology capable of producing inertial confinement fusion energy. The accelerator, which, in a sense, is nothing more than a scaled-up Leyden jar, generated a 210-trillion-watt pulse of X-rays. These X-rays can be used to implode minute fusion fuel pellets to the high densities and temperatures needed to ignite nuclear fusion reactions, like those from which the Sun and hydrogen bombs derive their energy outputs. As in the case of Benjamin Franklin, the Sandia Z "Leyden jar" is discharged into wires. But in this case, the electrical pulse is far greater—millions of volts and millions of amperes of current. Three hundred thin wires form a cylindrical configuration about the size of a thimble. The fusion fuel pellet can be placed in this thimble.

The secret to the success of the Sandia system is that the energy of the electrical pulse passing through the wires is not immediately dissipated, but rather is stored in magnetic fields generated by the flow of the current through the wires. But once a breakpoint is reached, the energy stored in the self-generated magnetic fields is efficiently coupled to the electrons of the wire and the resulting electron heating generates the burst of X-rays. As a result, the X-ray burst is much more intense than the original electrical pulse. In this way, the power level is "amplified" to a point required to generate thermonuclear fusion.

During the mid-1980s, scientists working at the Nevada nuclear weapons test site were able to demonstrate that these small fusion pellets could be ignited by the type of X-ray bursts that would be generated by high-power lasers and pulsed power sources. This was done in the Halite-Centurion program utilizing small nuclear weapon detonations in a contained chamber. The specially designed nuclear device generated a burst of X-rays at the intensity and energy level projected for future laser and pulsed power sources. The targets were successfully ignited in this way.

The necessary energy and power levels were found to be a bit higher than previously forecast with existing types of fusion pellet designs. The requirements were several megajoules of energy, at several hundreds of trillions of watts of power for high-energy laser generation of the X-ray burst needed.

The Sandia Z accelerator has improved from a power level of 40, to 210 trillion watts in the past 10 months. Another improvement by a factor of five is projected as being required for full-scale ignition of fusion. The Z accelerator has demonstrated that the technology for doing this is well in hand. Sandia projects that its next accelerator will have an output of 16 million joules at a power level in excess of 1,000 trillion watts. This machine will cost about $300 million.

The processes utilized in the Sandia system involve a series of stages and greater and greater densification of energy flux, culminating in the z-pinch itself. First, a series of capacitors are slowly charged up with electrical charge. Then a fast-acting electrical switch releases this stored energy as a powerful electrical current pulse with tens of millions of amperes of current at several million volts. The pulse reaches a power level of 50 trillion watts, or 50 terawatts. The electrical pulse lasts less than a couple of hundred billionths of a second. This tremendous densification of electrical energy flux is achieved through utilizing special geometries in the electrical circuit to shape the electrical pulse in space and time. Also, magnetic insulation is utilized to prevent premature breakdown and sparking of the main pulse before it reaches the target z-pinch configuration.

The apparatus in which this is done is the PBFA-Z (Particle Beam Fusion Accelerator) at the Sandia National Laboratory in New Mexico. The PBFA-Z looks like a large swimming pool, and actually utilizes water as the chief electrical insulating material. The Strategic Defense Initiative, despite its curtailed nature after 1984, has made significant advances in pulsed power technology over the past 15 years. But only when the attempt to utilize light ion beams to drive implosion of pellet fusion failed to work out, did serious consideration of the Sakharov approach begin again after 50 years. The chart on page 28 plots the progress achieved since the Sakharov z-pinch approach was taken up in 1995.

The Plasma Z-Pinch

The key to success of the Sandia PBFA-Z in achieving a 210-terawatt X-ray burst is the operation of the plasma z-pinch. The scientists who have created this stunning breakthrough report that they really don't know why it works so well. As they describe it, the 50-terawatt electrical pulse is directed into 300 thin wires, which are each about 2 centimeters long, and are configured in a cylindrical geometry about the size of a thimble. The electrical pulse passing through the thin wires turns them into high temperature plasmas. But rather than immediately blowing up, the electrical current passing through the thin wire plasmas generates a large magnetic field. This magnetic field "pinches" the wire plasma to smaller and smaller diameters, which increases the current intensity of the electrical pulse, which increases the intensity of the compressing magnetic field. In the process, a greater and greater energy densification is created. That is, the electrical pulse energy is transformed into a more compressed magnetic field.

As this pinch process reaches some limiting condition, the magnetic field configuration breaks up, and the magnetically stored energy is suddenly transferred to the electrons of the wire plasma. The motion of the energized plasma electrons then generates the 210 terawatt pulse of X-rays.

This intense pulse of X-rays can then be used to drive the implosion of a standard type of laser fusion fuel pellet in the same way that is done in the hydrogen bomb, which gets its driver X-ray pulse from the atom bomb. Or, the X-ray pulse can implode a magnetized fusion target. This last approach is the most promising, because it combines magnetic confinement with inertial fusion.

The Ampère Force

The reason that the scientists are surprised by the performance of their wire z-pinch plasmas is that the ordinary Maxwell approach to electrodynamics predicts that the configuration should immediately become unstable. But it does not happen.

These scientists, in fact, are really seeing the breakdown of standard Maxwell theory; they are faced with a physical singularity which is totally inexplicable from the standpoint of ordinary macroscopic electrodynamics.

This type of breakdown of ordinary macroscopic electrodynamics was actually forecast by the true originator of electrodynamics, the great early 19th Century French scientist André-Marie Ampère, and the two great German scientists, Carl Gauss and Wilhelm Weber, who expanded upon Ampère's experiments.[1]

To put the question in a nutshell, an iron atom may appear to be the same when it is part of non-living matter, like a piece of ore, and part of living matter, as in hemoglobin in the blood. It is actually entirely different both in terms of its capabilities with respect to physical action, and in terms of its physical geometry—its configuration of electron orbitals, for example.

As Gauss insists in his letter to Weber of March 19, 1845, Ampère's electrodynamics includes a very small repulsive force, which, as Gauss notes, is extremely difficult to detect in ordinary laboratory experiments. Nevertheless, Gauss criticizes Weber's proposal to ignore this "Ampère Force," and insists that this is the cornerstone of Ampère's electrodynamics. Twentieth century electromagnetic science has ignored this Ampère hypothesis, and finds both the atom and the nucleus to be mysterious entities requiring an entire new range of forces and mechanics.

The Ampère repulsive force is directly proportional to the electrical current. And it could very well be that the Sandia PBFA-Z high current pulses are accessing a regime in which the Ampère repulsive force can no longer be ignored.

Notes

1. The background and import of this work is developed in Laurence Hecht, "The Atomic Science Textbooks Don't Teach: The Significance of the 1845 Gauss-Weber Correspondence," *21st Century*, Fall 1996, p. 21.

The Analytical Prison of

by Christine Bierre

Why creativity cannot coexist with René Descartes's philosophical formalism.

EDITOR'S NOTE

Although this was written for a French audience, the problem of Cartesianism knows no national boundaries. The thoughtful reader will find analyzed here the root of that destructive formalism which imprisons the mind of so many otherwise creative people, trained in the pure sciences. This is the author's translation of her article "Descartes: La Prison Analytique de la Pensée Française," which appeared in the French-language magazine Fusion, *March-April 1997. The author notes that this article was inspired by the recent works of Lyndon H. LaRouche, Jr., the American philosopher and political economist, notably by his works "The Essential Role of 'Time-Reversal' in Mathematical Economics" and "On the Subject of God."*[1]

The year 1996 marked the 400th anniversary of René Descartes's birth. Does anything remain to be said about Descartes today? Throughout the year, specialists analyzed his works, the press covered him at length, and conferences took place, one after the other, in the honor of this man, the mere mention of whose name evokes that of the nation of France! But as an interesting sign of the times, the mood of those attending the ceremonies was rather morose, a bit like that of people who attend Catholic Mass only to respect traditions and to honor rituals. . . . Could France possibly be ready to break out of the Cartesian fishbowl in which it has imprisoned itself for centuries? Will the crisis that is breaking out at all levels sweep away those axioms so clear and those qualities so obvious (*evidences)* supposed to lead infallibly to truth until the end of time?

The climate is rapidly turning toward iconoclasm in France today, and this is not necessarily a bad thing, on condition that we know the idol we want to destroy, and we replace it with a more advanced concept allowing us to improve our grasp of reality. Do not destroy everything indiscriminately! The risk would then be to fall again into the same mistakes; worse even, into a sort of purely arbitrary deconstructionism. Be sure of one thing: There are worse things than Descartes! The difficulty of the task of replacing this idol arises from the fact that we cannot examine it as something that is external to us, like a statue that we can contemplate from afar. We must ascertain that when we put Descartes on the guillotine, it is not our own heads that fall—this idol is within ourselves, and the only way to overcome it without too much self-destruction is to know ourselves.

Is Descartes the cause of French Cartesianism, or is it France that has caused the existence of a Descartes? This question is likely to remain unresolved, so much are these two things intertwined. What is important, however, is to know that there is a Cartesian hypothesis—a system of axioms, postulates, and principles—through which the French population apprehends and defines its action in the world. The problem is that this system is defective; like a prism, it gives us an image of the world which is systematically deformed and whose effects on daily life are disastrous. Unfortunately, the Cartesian abstractions are not mere fantasies with no effects on reality. Just as "The Method" leads to numerous errors in physics, a Cartesian influence among those holding official responsibilities leads society into impotence and a complete inability to solve its existential problems.

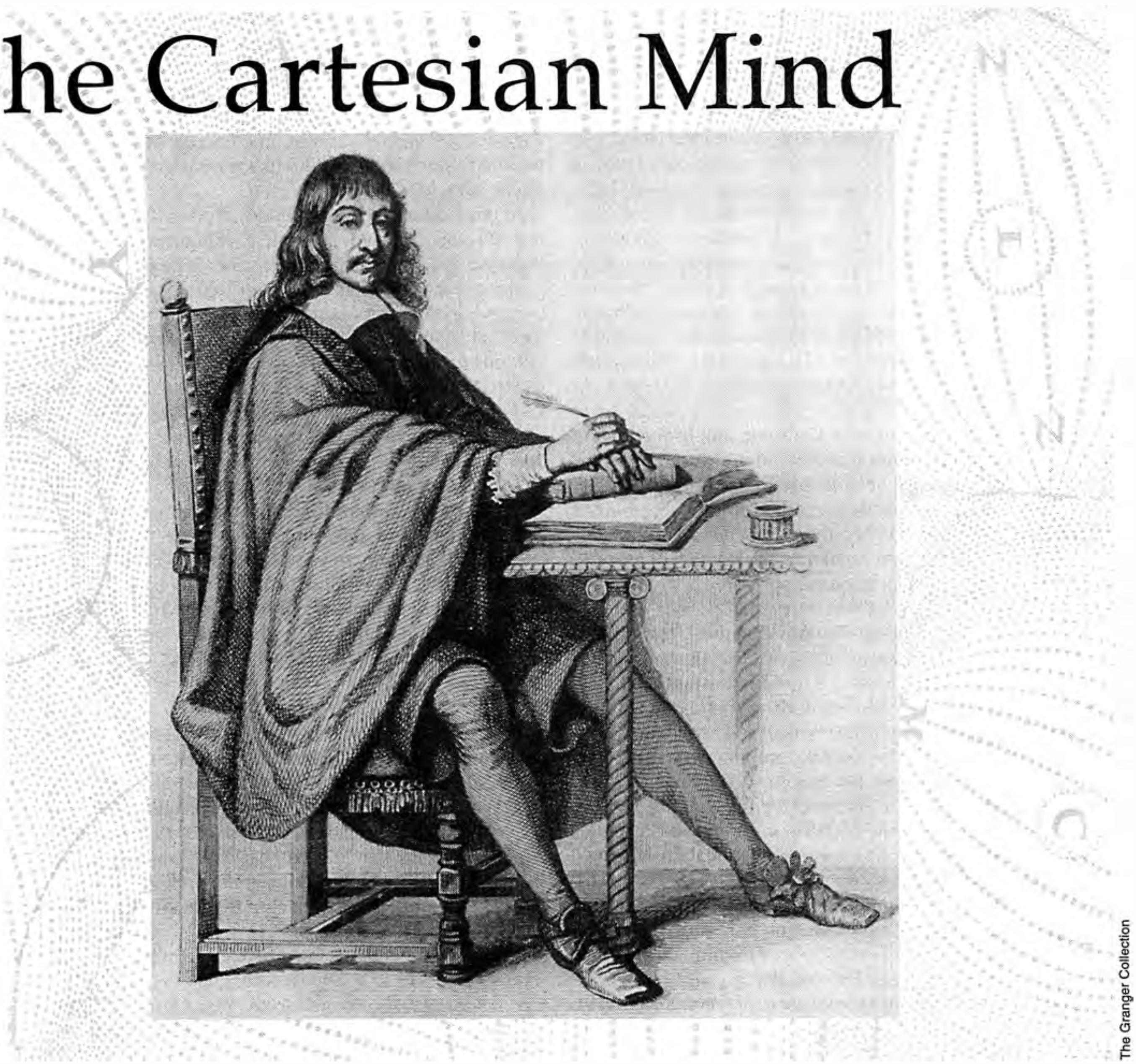
What is the portrait of the Cartesian? The cartoon images of the French man, wearing his Basque beret and carrying a bread baguette under his arm, and the sexy French child/woman à la Brigitte Bardot are long gone, thank God. Today we must deal with another cartoon image, however, a more "complex" one, that of the "reasoning" Frenchman In the image of Descartes's *Cogito ergo sum*—"I think, therefore I am"—the Frenchman loves reasoning, and that's a good thing! But it remains to be seen whether this Cartesian way of reasoning really leads him to reality.

The first principle of the Cartesian is to ban all naïveté and emotional spontaneity from the process of reasoning. By always distancing himself, and mistrusting and doubting everything as a means of arriving at truth, his "critical" mind has long since killed these qualities. The same goes for simplicity of thinking—the mere mention of this quality provokes a cry of horror from our Cartesian: "Simpleton! It's in the complicated that our thought lives and flowers. Things are always a bit more complex than that," he says, striving always to push the analysis further, cutting each split hair in four, doubting ever to be able to reach those most evident elements of thought. . . .

What about ambiguity, unresolved paradoxes which incite the mind to work toward new solutions? It's been years since our Cartesian purged the French language, thought, and writing from any such "impurity" or "obscurity" which might threaten it. Ideas must be clear, deduced in a perfect order going from the more complex to the simple, and from the simple to the more complex, as in a mathematical theorem. And what greater source of errors can there be than eruptions of subjectivity and emotion? We must rid thought of these forever. . . .

As for categories, beware mixing up the genres! How can you talk at the same time about economics and philosophy, about art and science, and pretend to a true knowledge? Each domain of knowledge must remain pure and separate, for fear

the Cartesian Mind



René Descartes (1596-1650), framed by an engraving of his vortices, or whirlpools, from the Principia Philosophiae, *1644. He envisioned these vortices as carrying the planets and stars through space.*

of being contaminated by any other. Isn't it in honor of Descartes, of his desire for order and clarity, that pure mathematics, without the "impurity" of physics, today reigns over all the sciences in France and constitutes the determining criteria to select the good from the bad student?

Fortunately for our Cartesian, whose life could start becoming quite difficult with all these constraints, he has the "perfect" method to reach truth. "Ouf!" he says, "I'll finally free myself from errors, those awful mistakes which ridicule us in front of others and threaten to reveal to all the world what we want to hide at all costs: how bad we are. . . . Descartes offers us a sure method, an error-free path to truth. And if pure mathematics does not suffice to do the job, a little punishing will help to enforce the method. What more could one desire?"

It matters little whether those concepts provoke fear and impotence to act in a good number of citizens. Indeed, one acts only when one knows what one wants. Thus, if before acting, you have to doubt everything, reduce all thoughts to their fundamental elements, and avoid any possibility of error, who can still dare to act? Even Descartes was fully aware of this danger and advised his readers not to follow his philosophical method when it came to daily life but, rather, to call upon a more pragmatic morality in order to decide what to do. This is the reason that many citizens, paralyzed, do not dare to write, intervene, or take initiatives or responsibilities in public life; for this reason, most "intellectuals" limit themselves to "giving lessons." Nobody dares to create. Fearing any risk, one would rather call upon specialists, experts of all sorts, ENA (Ecole Nationale d'Administration) graduates, and personalities covered with diplomas, even when it becomes obvious, as today, that all these personalities have failed to find the solutions to the very existential problems of society.

Pretending to love reasoning but castrated of all possibility of powerful intervention, unable to transform the world, our Cartesian becomes cynical, spying from the corner of his eye with envy on all those who manage to create, and living in ferocious competition with all the others. Instead of taking a vigorous approach to the search for truth, fearing mistakes, the Cartesian adopts a "prudent" attitude toward knowledge, which allows him rapidly to cover himself in case of an error: "Do not make me say what I have not said," he screams, happy to have manicured his language in such a way as to be able to pretend he never said this or that.[2] To impress the entire world, he "borrows" from others what he is unable to discover himself.

And how rigid he is, our poor Cartesian, imprisoned in the yoke of such a mathematical, formal order, dreaming to himself of the moment when he will dare to revolt, or at least, of those torrid earthly pleasures which would enable him to break, even for a brief moment, the bars of this golden prison! It is here that our Cartesian abandons the domain of analysis and falls on his feet, or rather on his posterior . . . soon coming back, however, to the rules of the game.

What it is in Descartes's philosophy that produces such effects, we will try to analyze in this article. The aim of this exercise, however, is not to plunge the Cartesians—that is, our fellow citizens—into deep contemplation of their belly buttons. Rather, we are responding to the political and economic storms that are threatening France, Europe, and the world today. In France, unemployment and financial insecurity have hit one working person out of four. A financial crisis could explode at any moment, provoking the collapse of the world economy, and considerably aggravating the deep political crisis hitting our countries already.

The scientific world is not spared by this crisis, as one can see in the cuts in research budgets, the consequent aging of scientists, and the early retirement of some of our best thinkers. More deeply, the French scientific world bears the mark of Descartes's influence in two major ways. First, scientists have a tendency to take refuge in an ivory tower of thinking, separated from developments in the real world: Descartes himself said that the place where he liked to think the best was in his bed! How many scientists do their jobs today as something totally separate from reality? Second, the French scientific world today gives too much importance to abstract and theoretical modelling, over experimentation led by the principle of hypothesis. How many "leaders" in the theoretical domain, men who rarely try to conform their theories to reality, still occupy official positions of great importance? This tendency is devastating, because political measures are adopted on the basis of totally erroneous computer models like those in the areas of alleged global warming, the ozone hole, and greenhouse effects.

It is in this context that the validity of Cartesianism must be put into question and citizens redirected to other sources of inspiration better able to arm them to bring about useful transformations in society. In France, some of the greatest names which come to mind in the history of statecraft and economics, of people who potently transformed their societies, are those of Louis XI; Henry IV; Maximilian de Béthune, Duke of Sully; Jean Baptiste Colbert; and Charles de Gaulle. In the area of sciences, the currents of Blaise Pascal and of the French Academy of Sciences founded by Colbert, as well as those of Gaspard Monge and Lazare Carnot's École Polytechnique are traditions much more fruitful to societies than that of the formalist-empiricist Descartes.

At this moment, love for philosophy has taken over the nation of France. In cafes, at municipal cultural centers, in public libraries, and in schools, people gather to participate in heated philosophical debates. As never before, authors have attempted, in a series of best-selling books, to make great philosophical arguments accessible to a broad public. Everywhere, citizens call on philosophy to find that "reason" for things which they can no longer get through official religions or political doctrines, in a world where the political, economic, and social crises have blown all dogmas apart. These "natural" Socrates, who claim to bring wisdom to people, will have to respond to a troubled world. Will they inspire men and women to fight for the good, for wisdom, for creating a society which ennobles them and makes them better than themselves? Will they be able to educate good captains who can lead society safely to port in the coming tempests? Any philosophy which does not prepare man to mature for the troubled times to come, would be nothing more than vain academic endeavor, or Cartesian escapism into abstract analysis.

Cartesian Dualism

In order to understand the problems posed by Descartes's philosophy, one has to situate it in the context of the two main currents of thought which, like two absolutely opposite poles, embrace in their breadth all of the philosophical tendencies. Man has always attempted to understand and to define the nature of everything that is. There he sometimes finds things that seem to belong only to the domain of mind—such as courage, justice, the good, intelligence, or the idea of God. To those ideas he attributes the qualities of unity and permanence. Such ideas participate in unity, because we can talk about a general concept of justice or goodness which transcends all the particular notions of justice or goodness. They participate in permanence, because they resist time and particular historical periods. For these reasons, these ideas are called *universals*.

Besides things which belong to the domain of mind, man finds in the world a substance of a different nature which he has defined as matter: minerals and all that is inorganic, as well as plants, animals, and everything organic. To matter, he has attributed the qualities of multiplicity and temporality. Indeed, opposed to an abstract concept of "stone," which does not signify any particular type of stone, matter is of a multiple and plural nature: One talks thus of marble, of bauxite, of limestone, of precious stones, among other sorts of stones existing in nature. Matter is also of a temporal nature—it suffers transformation, and it comes and goes.

The great question which has always haunted human beings is, what is the importance of each of these domains, and what is the relation between them? In the beginning there was the Word—God, a principle, an immaterial cause that causes everything that is. This is the belief of the great religions or philosophical currents, which subordinate matter to transformation by the domain of mind. False, exclaim the others, defending the opposite version. In the beginning, there was matter, which, in its evolution, generated the things of the mind. For the former, reality is situated within the realm of the spiritual One, the source of everything that is; for the latter, the source is the material Many, the primordial bricks out of which the entire universe, including that of ideas, is built.

The difficulty in defining the relation between those two realms is the subject of Plato's famous dialogue *Parmenides,* the most challenging text written by this wise man, pushing thought pitilessly into every corner of that One and that Many which we are trying to define. The lesson of the *Parmenides* is that by favoring the Hypothesis of the One and only One, over that of the Many and only Many, and vice versa, we arrive only at paradoxes, insurmountable antinomies. Indeed, the One which generates the Many, doesn't it itself become Many in so doing? And how does that One which just generated the Many, exist in that Many? Is it similar to a tablecloth, where each part of the cloth covers a part of the table? Or does it exist as a whole, present in each of the table parts? If it is similar to the tablecloth which covers each part of the table, then the One would no longer be a One, since it could be divided into parts! On the other hand, how can something that participates in the domain of ideas be created out of something material, without any problems?

Depending on whether currents of thought take this or that side of the paradox, we get either the materialist, empiricist, and logical-positivist currents, if the starting point is that of matter, or the idealist and religious currents, if the starting point is that of unity. Most of the time, however, both systems of thought lead to an incomplete man: either an abstract man with his head in the clouds, rejecting the material component of the world, a rabid formalist constructing empty structures; or a concrete man, his feet solidly cemented in matter, indistinguishable from the beast because he is incapable of elevating himself to the domain of ideas. This is the case of the various materialisms.

Between these extremes one finds mainly dualisms: an abstract man whose thought is ruled by empty formalisms but whose feet are moved by the vertiginous motion of matter. Like puppets whose heads and feet are agitated by their own internal rhythms and logics, these dualisms are incapable of explaining the existence of a complete man, soul and body, mind and matter, according to coherent laws governing the totality, from top to bottom. This is particularly the problem of Descartes. The solution to the *Parmenides* problem, we shall see in due course, is not to be found either in the abstract and dead One of the formalists, or in the material Many of the empiricist—the two extremes of an Aristotelian fishbowl that imprisons the mind. Instead, the solution lies in a process of permanent transformation, in which a dialectical movement between the One and the Many creates the conditions for going from one axiomatic universe to a more advanced one, and then to a yet more advanced one, in a process of constant evolving toward perfection.

The Analytical Obsessions of Descartes

A certain religious tradition attempts to present Descartes as the first Christian philosopher to have dared to use science to understand the physical universe and its evolution. Descartes would be, in this tradition, the father of materialism at a time when a "Creationist" church held *Genesis* to be the sole explanation of the universe. This is totally false. From St. Augustine to the scientists of the Renaissance, and in particular, Cardinal Nicholas of Cusa, the Platonic current in Christian thought worked to develop a metaphysics which, with the help of reason and science, would be able to account for God and His creation as a coherent whole. This current, to which we owe all major scientific progress (in only apparent paradox), is not a materialist current—as we shall see later regarding the dispute between Leibniz and Descartes.

The problem of Descartes arises from the very beginning with his flight forward into analysis and abstract thinking, a problem that leads him to conceive the domain of mind as being totally separate from that of matter. Even though these two domains are totally distinct from one another, we must still be able to determine those laws allowing them to coexist and complement each other. Descartes, however, is unable to establish a coherent link between them. He is, in particular, unable to show how the domain of mind organizes and gives directionality to that of matter. Matter becomes, therefore, an object of study in itself, a self-sufficient *mechanics,* and that is why certain Christian layers denounce the smell of "sulfur" around Descartes.

The analytical fixation of Descartes, a clinical one, appears from the very outset in his first work, *Regulae ad Directionem Ingenii (Rules for the Direction of the Mind*), which was written between 1626 and 1628, but published only in 1701, after his death.[3] In this work, Descartes attempts to lay the basis for a new, absolutely pure science, allowing him to avoid all error and to walk on the sure path toward truth. His fear of errors and obsession with a totally aseptic method which, thanks to an implacable logical rigor, would permit him to go from the more complex to the simpler and vice versa, would make Freud snicker. Frightened by change, emotion, and disorder—that is, by life—the analytical personality constructs abstract formalisms to give itself the impression of having everything under control.

Perfectly pure, this new science must call upon the only discipline that, in Descartes's eyes, has this degree of purity: mathematics. It must, however, go beyond mathematics to be the most universal possible, as Descartes says in Rule One:[4]

> For the sciences as a whole are nothing other than human wisdom, which always remains one and the same, however different the subjects to which it is applied.

The study of this new science is that of the most abstract, the most simple, and most general elements of all that is: the order and measure of all things—figures, sounds, or celestial bodies.

All is not false, of course, in this statement, because every system of thought needs axioms, the cornerstones upon which all thought constructions are built. Does the Cartesian axiomatic system correspond to reality, however? That is the real question which we must answer.

As one can see, Descartes locates his new science in the domain of pure intellect. In opposition to the empiricist school of Francis Bacon and Thomas Hobbes, which was quite in vogue in England and elsewhere from the end of the 16th century, Descartes rejects matter and experience as being a point of departure or the key to reach truth. All knowledge that comes through experience or the senses is, for Descartes, necessarily confused and inexact. One could say thus, apparently, that between the two broad currents of thought which we outlined in the beginning of this article, Descartes stands, from the standpoint of method of thinking, on the side of the One and the Universals, whereas the empiricists, on the contrary, rely on matter and experience. We shall see, however, that Descartes ends up joining the empiricists. Thus, although the empiricists seek "in matter" those solid, indivisible atoms which, by assembling themselves, constitute the reality of the physical universe, Descartes seeks "in mind" those essential abstract elements, the simplest and most evident concepts, the axioms and postulates of a system of thought. Descartes defines those essential elements as *absolutes,* ideas like those of God, causality, equality or inequality, resemblance or dissimilitude, and other universals of the same type.

How can one reach this evidence? Here, what is known as Cartesian *innéism* appears (from the French word *inneé,* meaning "innate" or "inborn"). *Les ideés inneé* are innate ideas originating in the mind itself. These traces of Augustinian and even Platonic influences in his system no doubt reflect Descartes's education at the Royal Jesuit College of La Flèche at Anjou. In order to reach these simple and self-evident thoughts, experience, which is "often deceptive," must be rejected,[5] and one must use rather "intuition"—not that which comes from confused images of the senses, or from unfounded imagination, but the intuition that is the "indubitable conception of a clear and attentive mind, which proceeds solely from the light of reason."[6] Those ideas are "inborn" to us, says Descartes, borrowing Plato's concept that all learning is reminiscence of ideas present in our minds at their conception. In order to find these ideas, one should simply recall them with the help of the natural light that God has given to us.

Once these innate absolutes are discovered, one must deduce from them, in order, and proceeding carefully, slowly, and distinctly, all relative truths.

This is the Universal Mathematics through which Descartes promises to go infallibly in the direction of truth. Once again, the approach is totally opposite to that of the empiricists. Stuck to matter, the empiricist proceeds by induction—the idea that one can reach truth starting from the concrete experience of a specific fact, which one can assume, after having confirmed its veracity several times, will always be true. The example of the sunset is perfect to understand the inductive process: Yesterday the Sun set, today it did too, and we can assume without much risk, even though we have not experienced it yet, that it will always set in the future. Descartes, on the contrary, uses the deductive method: Starting from the most abstract, general, and universal concept, he claims to be able to deduce all the specific and relative truths.

If we follow that deductive process in perfect order, he states, we cannot be wrong, because the process of "inferring" relatives from absolutes—the case of the syllogism "all men think, Socrates is a man, therefore Socrates thinks"—"cannot be wrongly done even by the mind the least capable of reasoning"![7]

This is, therefore, he says, the basis of the new science:

> By "a method" I mean reliable rules which are easy to apply, and such that if one follows them exactly, one will never take what is false to be true or fruitlessly expend one's mental efforts, but will gradually and constantly increase one's knowledge till one arrives at a true understanding of everything within one's capacity.[8]

In *Discourse on the Method (Discours de la méthode),* Descartes rhapsodizes ecstatically on these deductive chains of reasoning:

> 11. Those long chains of totally simple and easy reasonings of which the geometers are accustomed to make use in order to arrive at their most difficult demonstrations had given me occasion to imagine that all those things which can fall under the knowledge of men follow from each other in the same fashion, and that, provided only that one abstain from accepting any of them as true, that not be, and that one always keep to the order that is necessary in order to deduce the ones from the others, there can be none so remote that one does not finally reach them, nor so hidden that one does not discover them.[9]

The grave problem of a logical-deductive approach, however, is that it does not permit discovery or creation of anything fundamentally new.[10] Rather, it limits itself to what Descartes himself accuses Aristotelian syllogism of doing, in his *Principles of Philosophy (Principia philosophiae):* of being nothing other than a "dialectic that teaches the means to make others understand the things one knows already."[11] If Cartesian obviousnesses *(evidences)* are the cornerstones of a given axiomatic system, how can one move from one system to another one that is more advanced? Yet, in examining the history of the physical universe and that of society, does one not see that their existence has been characterized precisely by transformations and axiomatic revolutions? To comprehend those revolutions, neither induction nor deduction is of any help. Only creative thinking which proceeds by hypothesis allows us to understand and to provoke those types of transformations. Not taking into account creativity, the Cartesian is condemned to glide along the walls of his axiomatic prison, a bit like a goldfish who ends up knowing every corner of his glass bowl, but is perfectly incapable of getting out of it.

The Cartesian Metaphysics

After having established the rules of his logical-deductive method, Descartes turns to his metaphysics. In *Discourse on the Method* (1637), *Meditations on the First Philosophy* (1640), and *Principles of Philosophy* (1644), Descartes attempts to develop an ontology which explains God and His creation, the physical universe, as a coherent whole, while treating problems both of philosophy and of physics. *Discourse on the Method* is composed of a philosophical-biographical essay, followed by three scientific treatises, supposed to contain the main scientific discoveries of Descartes, *La Dioptrique (Optics,* the laws of light reflection and refraction), *Les Météores (Meteorology,* reflections on the nature of the rainbow), and *La Géométrie (Geometry,* analytical geometry—see Figure 1). The first part of *Principles of Philosophy,* a Scholastic version of *Meditations on the First Philosophy,* which Descartes wrote with the hope that the Jesuits would use it as a philosophy manual in their schools, is dedicated to "The Principles of Hu-

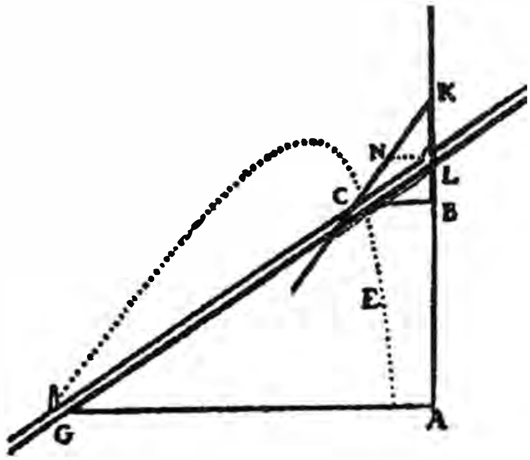


Figure 1
DESCARTES'S GEOMETRY
"All the points of [curves] which one can call geometric . . . have necessarily some type of relation to all the points of a straight line which can be expressed by some equation." With this conception expressed in La Géométrie, *Descartes is considered, along with Fermat, to be the founder of analytical geometry. The great error of Descartes, however, is to accept in his geometry only the "geometrical" curves, and not the "mechanical" curves such as spirals and tractrixes, because they are incommensurable. As Descartes writes, "One imagines them described by two separated movements which do not have among themselves any relation which can be measured exactly." This rejection of incommensurables, coming from a mathematician with considerable pretensions, is the reason that it was Leibniz, and not Descartes who, inspired by Pascal, made the most important mathematical discovery of this time: the infinitesimal calculus.*

man Knowledge." Three other parts, "The Principles of Material Things," "The Visible Universe," and "The Earth," follow, in which Descartes tries to apply his method to the comprehension of physical problems.

All of Descartes's errors appear starkly in those works, especially when he tries to deal with phenomena of the physical world. The essential axioms of his deductive method, those obviousnesses (*evidences*) that were to lead us infallibly to truth, are incapable of explaining the nature of the physical universe. They are therefore totally wrong! Descartes's aberrations concerning movement, astronomy, the human body, and space-time are enormous, and remain there like historical monuments testifying to the incompetence of his method. Oh, no doubt, he committed many errors, some will say in his defense, but what great scientist didn't? He also made exceptional discoveries. We shall come to these discoveries, some of which strangely resemble the work of his contemporary scientists. In fact, Leibniz and others did not hesitate to accuse Descartes of outright plagiarism.

It is in *Discourse on the Method* that Descartes talks for the first time of his *Cogito ergo sum*, the famous "I think, therefore I am." How did he discover this first obvious axiom of his system? By the method of "methodical doubt," he tells us, an analytical process by which one puts everything one believes into question until one arrives at absolutely certain knowledge.

Why doubt everything? Knowledge transmitted by our senses often leads us to error, says Descartes, and this is also true for knowledge transmitted by the intellect; after all, don't we confuse dreams with reality? By using this methodical doubt, Descartes realizes that he can put everything into question, everything except his own existence and the fact that he thinks. Even if everything that he thinks is erroneous, it necessarily follows that the thinking is being done by someone, and, that in so doing, he, the thinker, exists. From this he arrives at his first conclusion: I think, therefore I am.

From this first obviousness (*evidence*), Descartes infers a second one: the absolute difference between the nature of the human soul and that of the body. To arrive at this conclusion, Descartes considers that all upon which one can cast a doubt is actually "false," and that only thought, therefore, has any real existence. This "sophism," as Leibniz calls it—because the mere fact of putting something into doubt cannot lead us to characterize it as "false"—leads Descartes to declare the absolute superiority of mind over body, radically separating the two domains. Descartes goes so far as to affirm that

> . . . seeing that I could feign that I had no body, and that there was no world, nor any place where I was; but that I could not feign, for that reason, that I was not at all; and seeing that, on the contrary, from the very fact that I thought of doubting the truth of other things, it followed very evidently and very certainly that I was; whereas, on the other hand, if I had simply ceased to think, even if all the rest of that which I had ever imagined had been true, I would have had no reason to believe that I had been: I knew, from this, that I was a substance the whole essence or nature of which is only to think, and which, in order to be, does not have need of any place, and does not depend on any material thing. Thus this "I," that is to say, the soul through which I am that which I am, is entirely distinct from the body, and is even easier to know than it, and, even if the latter were not at all, the soul would not cease to be all that which it is.[12]

One can see that Descartes arrives here at an extreme form of spiritualism. Pretending that in order to be, man needs nothing that one can attribute to bodies, is practically tantamount to attributing to man a divine nature. Descartes will be unable later on to re-establish a coherent link between those two domains of mind and body.

God, the Infinite, and the Final Cause

Having thus defined human nature, Descartes goes on to explain the nature of God. Let us underline here, in order not to shock some of the secular mentalities, that all the problems posed by Descartes in religious terms can be understood as well when posed from a philosophical standpoint. Descartes says we cannot know the nature of created things without first knowing the nature of God, the First Cause of everything that is. To prove the existence of God, Descartes uses the ontological proof, whose essential argument is the following: Whence comes to us the idea of a perfect being, of God? It cannot come from nothing, nor from us directly, since nothing which is more perfect can come from something which is less perfect. It can therefore come only from God Himself. But, how can one prove His existence? The ontological proof calls then upon a logical-deductive argument, according to which, if God is "perfect," then He must also "exist," because the attribute of "existence" is necessarily included in the idea of "perfection."

Until this point, there is nothing that is not traditional to Christian thinking. The deep problems of Cartesian metaphysics appear, however, in his concept of God and in the relation he establishes between God and human beings. Descartes's "lazy" God, who created once and for all, going to sleep after having put the world into motion, generates insoluble paradoxes. How can He, for instance, be omnipotent and omniscient if, having stopped creating, He can no longer intervene or know what is happening in the order of creation? That God would be therefore impotent!

Descartes's God is confronted by the same problems as Newton's *deus ex machina:* the friction that accompanies and uses up all motion in nature will lead sooner or later to a total halt of the universe. What will God do then? Will He come back to Earth like a clockmaker, to rewind its universal mechanics, as Newton imagined?

The problems continue when Descartes describes the difference in nature between an infinite God and mortal human beings. From this difference, which is indeed quite real, Descartes draws the totally wrong conclusion, however, that it forbids finite human beings from any approach toward the infinite nature of God:

> 26. We should never enter into arguments about the infinite. Things in which we observe no limits—such as the extension of the world, the division of the parts of matter, the number of the stars, and so on—should instead be regarded as indefinite.
>
> Thus we will never be involved in tiresome arguments about the infinite. For since we are finite, it would be absurd for us to determine anything concerning the infinite; for this would be to attempt to limit it and grasp it. So we shall not bother to reply to those who ask if half an infinite line would itself be infinite, or whether an infinite number is odd or even, and so on.[13]

Descartes's refusal to get involved in disputes over these notions left him out of the main scientific debate of his century, which led to Leibniz's discovery of integral and differential calculus. For the notion of *infinite,* Descartes substitutes "indefinite": when one has the impression that something has no limit, we shall not say that it is infinite, but only that it is indefinite, since it may have limits we cannot determine. Descartes then prohibits any attempt to understand the final causes of God in the Creation:

> When dealing with natural things we will, then, never derive any explanations from the purposes which God or nature may have had in view when creating them [and we shall entirely banish from our philosophy the search for final causes]. For we should not be so arrogant as to suppose that we can share in God's plans. We should, instead, consider him as the efficient cause of all things; and starting from the divine attributes which by God's will we have some knowledge of, we shall see, with the aid of our God-given natural light, what conclusions should be drawn concerning those effects which are apparent to our senses [and we shall be assured that what we have once clearly and distinctly perceived to belong to the nature of these things has the perfection of being true].[14]

The consequences of those ideas on the very nature of God and on the relations among God, man, and the whole of Creation are very grave indeed. There must be a coherent principle that allows us to comprehend (1) God, the Absolute or Transcending cause, as the philosophers call it, that is, the spiritual principle which generates everything that is and which participates in matter; (2) the Creation, which although participating in matter, must reflect generally the spiritual cause that engendered it; and (3) among created things, the specific role of human beings who, being the closer to that Cause, alone are able to comprehend it, even if in a limited fashion.

This is no small affair. Descartes forbids humans from understanding that perfect model of which they are the living image! By refusing to man any real knowledge of the nature of God, and of His creative powers, Descartes wants to stop man from discovering those very qualities that make man "in His image": his own creative powers and capacity, as a "living" image of God, to transform the world, becoming, in Peter Abelard's words, the "small helper" of God in a process of eternal creation. Unable to know the creative powers of God, the Cartesian is unable to see how those creative powers are inscribed in the very heart of all Creation, organic and inorganic universe alike—contrary to the Leibnizian who, by studying transformations in the universe, makes of them the very object of his or her research.

Concerning scientific research, Descartes's rejection of final causes blocks the way to the most fruitful method of inquiry into the nature of things. Indeed, it is knowledge of the goal sought by a creator—be he God or human being—insofar as that goal defines the means used to reach it, which allows us to discover clearly each step of the process in the creation of something. The Cartesian limits himself to trying to grasp the "efficient" causes of things, those material causes that immediately cause and precede the events. The difference is the following: Was the discovery of America *caused* by Christopher Columbus's ships, the crew aboard, and the winds which pushed them, as the Cartesians believe? Or was the real cause, rather, the ideas and projects worked out by a group of scientists and navigators—Nicholas of Cusa, Christopher Columbus, Toscanelli, and Henry the Navigator—which gave the initial impulsion to the scientific discoveries and technical breakthroughs leading to the discovery of America? Was it the cannonballs falling on a fort that caused its takeover, or was it, rather, the war plan conceived and carried out by the general in command that was the real cause of the takeover?

In the first hypothesis of efficient causes, one limits oneself to knowing the "efficient" material causes having immediately created the conditions for the takeover. It is not totally impossible, but it is very difficult, to start from this particular standpoint to try to discover the aims and global deployment plan that prompted the cannonballs to fall where they did. In the second approach, however, that of final causes, knowledge of the aim sought by the general, and of his evaluation (hypothesis) of the situation, will lead us much more simply to unravel all the aspects of his deployment plan leading to the takeover of the fort.

We shall see the beauty and superiority of the approach used by Pierre de Fermat to discover the laws of light refraction, whereas Descartes, by proceeding with a percussive mechanics of efficient causes, was totally incapable of finding a solution to this problem. Does this mean that "efficient causes" are useless to knowledge? No. In the *Monadology,* Gottfried Wilhelm Leibniz (1646-1716), the great German scientist and philosopher, defines clearly the domain which corresponds to each of those causes:

> Souls act in accordance with the laws of final causes through their desires, purposes, and means. Bodies act in accordance with the laws of efficient causes or of motion. The two realms, that of efficient causes and that of final causes, are in harmony, each with the other.[15]

Matter Elevated to the Status of the Absolute

After "proving" the existence of God, Descartes tries to explain the relationship between God and the material universe. For this, he calls upon a notion of "substance," which he defines as something that does not need anything but itself to exist, as opposed to "attributes," whose existence is dependent on the substance of which they are attributes. The notion of *substance* is applicable to both God and created things, he says, with the provision, however, that in God, unlike in created things, substance is of a perfect nature. Of those substances, all existences can be reduced to two essential ones, says Descartes, a substance attributed to souls or immaterial things, and a different substance attributed to bodies or material things. Those substances, however, cannot be apprehended directly, because they are totally abstract principles. One can only know them through their main attributes, those from which all the other attributes derive. The main attribute of the soul is thought; that of the body is extension, whose nature is defined by length, width, and depth.

Thus, after having "proven" through the *cogito* the superiority of thought over everything that has to do with matter, going so far as to claim that only thought has any real existence or reality, Descartes, all of a sudden, grants matter the status of a relative absolute through this notion of *substance,* and puts it on an equal footing with the immaterial substance! Here we have our two principles, that of the spiritual One, which is unity, and that of the material Many—which acquires the same status of substance! The antinomy is thus intact, and the paradoxes are ready to appear at every street corner. We are at the heart of the Cartesian dualism.

Descartes's Physics

After formulating the idea of an abstract and dead intellectual substance, Descartes tries to sell us a notion of a matter that would be homogeneous, neutral, and devoid of any intelligence. Extension—a sort of linear continuity—constitutes the nature common to all bodies. Descartes's physics is a curious mixture of ancient Greek ideas, Scholastic beliefs, and a few

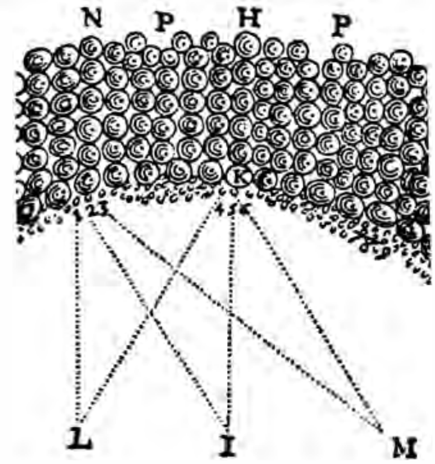


Figure 2
DESCARTES'S HARD-BALL APPROACH
Here, Descartes's mechanical approach is at a peak. He attempts to explain light refraction by describing the interaction among a multitude of hard balls.

modern elements. Descartes describes matter as an infinitely divisible, primordial-chaos type of substance filling the universe entirely and composing everything that is (Figure 2). This matter contains three elements: fire, air, and earth. Of the three, fire is the most volatile, its particles the most agitated. It is this matter which composes the Sun and the stars, and which transmits light to us, according to Descartes. The air, less volatile, is composed of larger particles than the Sun's. Its larger particles are like river stones with smooth edges. The Earth, finally, corresponds to solid bodies; these larger particles are the only ones that we can grasp with our senses.

Thanks to the laws of movement that God gave to the universe at its outset, and thanks to the conservation of motion, in particular, this formless matter enters into a self-organizing process. From this moment on, Descartes explains, it is only the laws of the universe created by God, and no longer God Himself, that contribute to the further perfecting of the world. The nature of these laws is material and mechanistic: thanks to movement, the elements of matter push and reject each other, shoving each other aside, taking each other's places, here dividing themselves, there recomposing themselves, in the midst of a totally full universe in which movement propagates itself throughout the spectrum, provoked by one small motion to the next.

Descartes distances himself from the Creationists, insofar as he believes that the universe became what it is through a long process of work of matter upon itself, and not six days of Creation. What he substitutes for Creationism, however, is totally mistaken: By reducing the physical universe to its mechanical causes, he bans from it everything which is of a transcendental nature, and thus he violates the spirit of a religion that attempts to give a coherent explanation of God and Creation. Indeed, if we are made in the image of the Creator, everything in the universe, each thing and every creature, must necessarily reflect, in a limited fashion and at its own level, His creativity and in-

"Donkeys at school," by Pieter Breugel. It is captioned by the artist: "One can always send him to school in Paris, but if he is a donkey here, it is not there that he will become a horse." Happily for our Cartesian, he has the "perfect" method to avoid "errors which ridicule us in front of others."

telligence. This is the problem of final causes.

The problems of Cartesian mechanism are multiple. Starting from the existence of a neutral and inert matter, into which God only afterwards instills motion, Descartes affirms that motion is not intrinsic to matter. This adds another paradox to those we have confronted so far: To the matter-spirit dualism, we must now add movement as a third element. Furthermore, one wonders how movement can conserve itself in a universe where God, after creating it and putting it into motion, went to sleep and no longer intervenes. Indeed, energy losses, friction, and wear provoked by motion would lead such a universe eventually to a total standstill, unless something were to come from the outside to compensate for energy losses. Descartes tries to respond to those difficulties by claiming that the quantity of motion is a constant in nature—an idea Leibniz demonstrated to be totally false.

Concerning space, Descartes's theories appear once again as running totally counter to those of the empiricists. For him, space is full of matter—while the empiricists conceive it as empty—and populated by hard and indivisible elementary particles constituting everything that is. This difference is only apparent, however, because both cases reaffirm the primacy of extension or matter as the reality of the physical universe. This is where Descartes comes to agreement again with the empiricists and the materialists. As for these latter, all the phenomena of Cartesian space-time limit themselves to those that can be explained by the three dimensions—length, depth, and width—and by the existence of figures and motions. We are, therefore, in a space-time that is reducible to lines and where everything can potentially be determined by the use of algebra. This is the space-time of Cartesian coordinates and analytical geometry.

The Cartesian cosmogony is equally wrong. According to Descartes, the motion of particles in his full universe leads progressively to the creation of vortices (Figure 3). At the center of larger vortices one finds the Sun and the stars, in smaller ones the planets. Descartes tries, with very poor arguments, to give an explanation different from Kepler's for the attraction exerted by the Sun over the planets turning around it. Johannes Kepler had intuited the existence of an electromagnetic type of force with the Sun its source. Kepler's method, however, is totally opposite to that of Descartes. Kepler started from the hypothesis that the motions of the planets around the Sun are governed by a universal harmony defined by the proportions that allow the series of Platonic solids to fit together, one in another. This geometrical hypothesis, coherent with the physical reality of the universe, allowed Kepler to discover his three famous fundamental laws of astronomy. Kepler's geometrical approach led him to the verge of a very modern relativistic concept of space-time, defined not by motion or by forces, but by curvature.

Descartes, quite the contrary, starts from a space-time defined only by extension and motion, and attempts to give a strictly mechanical explanation of the universe, rejecting all possibilities of magnetic forces or of action at a distance. His concepts of a volatile substance filling the universe entirely, and of a motion generating vortices, do not correspond to the deeper physical reality of the universe and lead to real aberrations. At a time when Kepler had already given the exact values of the elliptical orbits of the planets with the Sun at one focus, in his *Astronomia Nova* (1609) and *Harmony of the World* (1619), Descartes describes planets revolving in deformed circular orbits around the center of a vortex occupied by the Sun. The planets do not even *orbit* around the Sun, moving themselves, but are carried around by the fluid matter of the universe as it turns:

> Suppose that the whole of the celestial matter in which the planets are located turns continuously like a vortex with the Sun at its center. . . . In a river there are various places where the water twists around on itself and forms a whirlpool. If there is flotsam on the water we see it carried around with the whirlpool. . . . We can without any difficulty imagine all this happening in the same way in the case of the planets.[16]

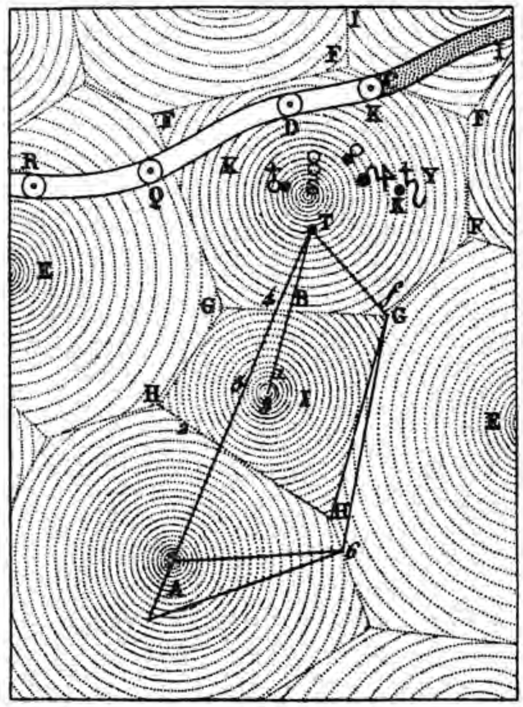


Figure 3
CARTESIAN VORTICES
According to Descartes, any movement of particles in a full universe generates vortices, in the center of which are to be found the Sun and other stars, and other, less important vortices, whose centers are occupied by the planets.

Leibniz: The Victory of Dialectics

How can one be sure that this Cartesian method is not viable? How can one verify any form of knowledge other than by examining whether it allows us to master the phenomena of the physical world? Many of Descartes's theories were not only totally in error, but were even delirious. At Ulm, Descartes heard voices in his dreams which inspired him to create the "new philosophy," advising him to develop a "poetic imagination," because it would be more fruitful than philosophy itself for the study of science. This idea is valid, on condition that the notion of poetry be rigorous and coherent with the laws of the universe; otherwise, imagination becomes delirium, especially after closing oneself in a small room with a hot stove for several days, as Descartes did at Ulm.

It is Leibniz who gives us the more advanced standpoint from which all of Descartes's problems appear clearly. Rejecting both the hypothesis of an absolute One (the abstract and dead universal of Cartesian facts) and of an absolute Many (the indivisible particles upon which, according to the empiricists, the universe is built), Leibniz furnishes a new hypothesis, much closer to reality.

We already denounced as false the idea that Descartes was the first Christian philosopher to reflect upon the laws of the physical universe and its evolution. The conceptions of Leibniz, who was almost a contemporary of Descartes, demonstrate the absurdity of such ideas. The very fact of being a Christian inspires Leibniz to want to understand all the beauties and perfections of the laws given by God to the universe. In this respect, Leibniz is a Renaissance man: He does not create dichotomies between faith and reason, between religion and science, and thus avoids entirely the matter-mind antinomy.

How does he overcome the paradoxes of the One and the Many? In the *Monadology*, the work in which Leibniz deals in the most rigorous and most general manner with epistemological questions, as well as in other writings, he establishes that those two domains of mind and matter, while fundamentally different, are coherently governed and related by the laws of God's pre-established harmony in such a way that all which is, from the infinitely large to the infinitely small, participates, in one way or the other, in mind *and* matter.

What is Leibniz's hypothesis, the axioms underlying his concept of the universe? At the heart of his pre-established harmony, one finds a constant process of transformation, where a one, which is a living and existing image of the Absolute One, plays a transcendental role in coherence with the domain of matter. For the analytical vision of a Descartes who dissects things into elementary particles, Leibniz substitutes a dynamic conception of the universe, a dialectics of transformation in which mind and matter, interlaced throughout the entire spectrum of Creation, each plays its own role: the mind, that of transcendental cause, generating and giving an intelligent direction to transformations; and matter, that of efficient cause, furnishing the support without which that transcendental cause could not even be.

Leibniz does not contest Descartes's idea of looking for the simplest elements constituting the universe: He merely rejects the Cartesian obviousnesses *(evidences)* and substances—an abstract soul and extended matter, sorts of purely mathematical absolutes which do not approach, in any way, the reality of being.

For Leibniz there *are* simple substances, the Monads, or essences of things that belong to the domain of the intelligible. In the *Monadology,* giving an example of those Monads that can only be understood by reason, while attacking the Cartesian notion of the "machine man," Leibniz explains that perception cannot be understood by its mechanical causes. Let us imagine, he says, a giant machine brain producing thought, perception, and sensations. The fact of being able to penetrate inside that giant brain would in no way lead us to discover anything about perception, and we would be wrong to believe that being inside and, therefore, better able to see the ways in which the elements of the brain act upon each other, would get us closer to understanding the nature of perception. This nature is nowhere to be seen in the machine brain as such, because the idea that organizes its functioning is not "visible"; it can only be discovered through the creative activity of our mind.

The opposite of the Cartesian Absolutes, Monads are not the lifeless foundations of an axiomatic system that is fixed until the end of time. In the image of that Absolute or Transcendental Cause, whose ideas generate everything which is, the Monads are intellectual essences that order and transform the material universe. They are not abstract or fixed entities, because transformation is intrinsic to their nature. It is, therefore, they who, through those transformations, generate, give life, direction, and harmony to everything that is. The Monads exist, however, in a harmonious relationship with composites, with material bodies, the whole being ordered throughout the Creation, in a coherent fashion, by God's preestablished harmony.

Let us try to imagine for a moment the universe that Leibniz proposes to us: It is a universe full of Monads and their composites, characterized by a constant process of intelligent transformation at all levels. Nothing, therefore, is of a homogeneous, continuous, or linear nature, as Descartes pretends with his notion of extension, which is a sort of "continuous whole," extending linearly like "whiteness in milk," as Leibniz puts it. For Leibniz, extension is relative, not absolute, because it can be divided. Looking into a microscope, Leibniz realized that the more one goes toward the infinitely small, the more the level of singularities, of Monads with their composites, increases.

The fact that transformation is axiomatic to Leibniz eliminates the dichotomy between space and matter or time. In a full space, made of intelligent transformation processes, the laws of transformation transcend and determine all the elementary characteristics of space-time. The essential characteristic of the universe that Leibniz proposes to us is, therefore, from the macrocosm to the microcosm, its *nonlinearity*—a universe irreducible to its linear, algebraic components or to figures evolving in a tridimensional space, as Descartes would have it.

It is his conception of God which allows Leibniz to avoid the paradoxes of the One and the Many. Indeed, if one admits an emasculated God, of Whom one cannot know the final causes, man will be limited to trying to comprehend the domain of mechanical and material causes. For Descartes's "lazy" God, who went to sleep after having created the universe, Leibniz substitutes a fully living God, eternally and from moment to moment animating this giant and equally living automaton, which one calls the universe, whose components are

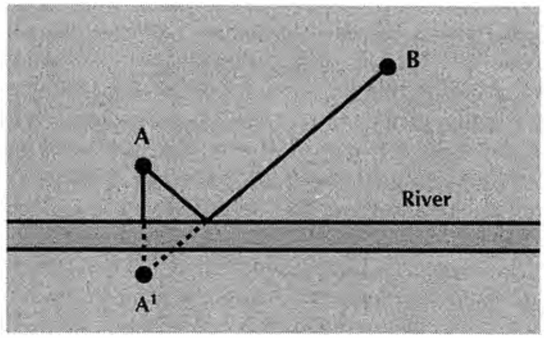


Figure 4
THE SHORTEST PATH
What is the shortest path that a rider A *can take to go back home at* B *after watering his horse on the river. If we project the exact distance of the rider at* A *from the river to the other side of the river, then we can draw a straight line from that point* A′ to B, *which is the shortest path the rider can take to go back home were he to be on the other side of the river. The point at which that straight line from* A′ *to* B *crosses the river, marks the place at which the rider must water his horse in order to take the shortest path back home. This is also the point at which a light ray going from* A *to* B *would reflect itself on a polished surface.*

all in His image. God, says Leibniz, never stops creating, and He creates through continuous fulgurations.

Nothing in God is arbitrary. He did not whimsically create something in place of which He could have created something different. Everything has therefore a sufficient reason for being. God, who is all perfect, also created the world with intelligence. That is why everything in the universe uses the shortest path, according to the Principle of Least Action.

Unlike Descartes, who believed that man was incapable of approaching the nature of God, for Leibniz, man made "in the image of God" is the only creature capable of understanding it, albeit in a limited fashion. Leibniz strongly advises human beings to try to comprehend God's final causes, the reasons that lead God to create in a certain way, rather than in another way. This method is the one which, according to him, is the most fruitful for understanding the laws of the physical universe, because it attempts to discover the ways in which divine thought applied itself to the transformation of nature. We have thus reached here a metaphysics that allows us to advance coherently from God the Absolute, to the comprehension of the physical laws of the universe.

In what way can our minds access that nonlinear universe, however? Is it through deductive logic, which limits the mind to a given axiomatic fishbowl? Or is it through induction, in which one keeps one's nose stuck to a particular sensuous experience while attempting to generalize that knowledge to all the other cases? What one wants to grasp in that universe are the laws governing the successive transformations which constitute its essence. Thus, hypothesis is the only form of thought capable of leading us to discover the new principles that transcend specific, and therefore limited, axiomatic sys-

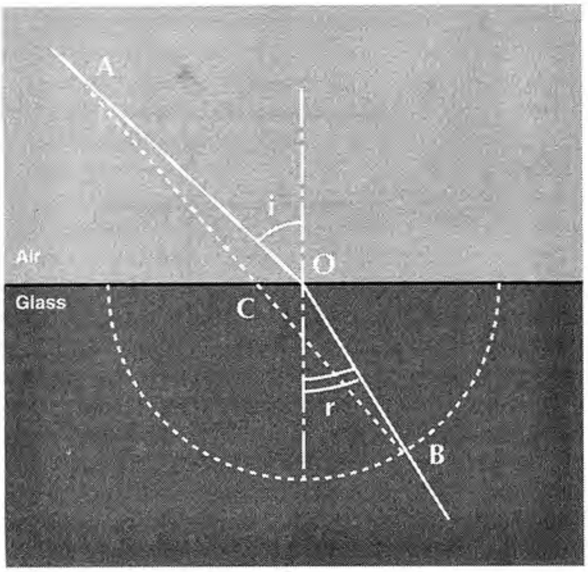


Figure 5
LIGHT REFRACTION
The dotted line leading us from A *to* B *and passing through* C *cannot constitute the least action path for that light ray. In fact, the light takes the path that passes through* O, *because on that path, it remains the longest time possible in the air medium, where it travels more easily, entering the glass medium, where it travels with more difficulty, only at the last minute.*

tems. The principle of discovery implicit in hypothesis is the only form of thought coherent with the reality of the physical universe. Leibniz replaces the analytical principle of Cartesian doubt with an approach toward truth guided by the formulation of hypotheses. One arrives at reality, not through dissection—can one understand life by cutting up a cadaver into its elementary pieces?—but by elaborating hypotheses that are true or false relative to a reality for which transformation is intrinsic.

Final Causes in Physics

Criticisms of Descartes are throughout Leibniz's writings. Because he was very active in France (the country where, after having studied Pascal's discoveries, he created his admirable calculus), Leibniz had to attack the intellectual hegemony of Cartesian thought.

Leibniz rejects Descartes's anal fixation on attempting to discover a method that will deliver us entirely from all errors: There will always be errors, Leibniz says, because of simple problems like fatigue or lack of attention. Similarly, he repeatedly rejects Descartes's methodical-doubt approach to truth, preferring to work with the notion of assent or, of reserve, which each thing merits. Regarding the Cartesian "evidence," Leibniz demands that it too be subjected to demonstration, not being exempt from axiomatic prejudices.

Numerous hypotheses of Descartes turned out to be totally false. In order to demonstrate the superiority of Leibniz's method, we shall deal here only with two of these hypotheses: the one on the conservation of motion, and the one by which Descartes claims to have discovered the laws of light refraction.

These two problems pose the question of the need for final causes in scientific research. When we try to determine the laws by which a light ray refracts when travelling from a lighter to a denser medium, what method do we follow? Do we try first to determine the physical nature of light, of the air, and of water, and the relations among these three? We would then be in the situation of that person who was trying to comprehend the causes of perception by entering a giant brain.

There is a much more beautiful way to solve this problem. God has created the most beautiful of all possible worlds, says Leibniz, a world which everywhere acts in the most intelligent of fashions. Nothing, he says, occurs in the universe without a sufficient reason, and everything that exists uses the shortest and most efficient path, the path of least action. It is by using this approach that Willebrod Snellius, the Dutch astronomer and mathematician, and Pierre de Fermat, the greatest mathematician of his time, according to Pascal, discovered the laws of light refraction. Leibniz, Fermat, and others were even persuaded that Descartes had plagiarized Snellius, who, just before dying in Holland in 1626, had transmitted his discovery to Descartes.

To realize this discovery, Snellius and Fermat, working independently, used the method by which the laws of the reflection of a light ray on a polished surface had been determined long before. Starting from the principle that light always takes the least-action path, scientists had discovered that the angles of incidence and of reflection of a light ray projected onto a surface are equal.

This problem can be easily understood when posed in the following way: Imagine a rider who wants to go back home but first wants to give water to his horse on the river (see Figure 4). What will be the shortest path for him to take in order to water his horse and return home? In this case, the shortest path is that of the straight line: If we project the point of departure of the rider *A* onto the other side of the river *A'*, we can from there draw a straight line between that point and the final destination of the rider, his house. The point at which the straight line cuts the river is the point where the rider should water his horse, in order to make the trip back home the shortest possible. It is also that point where the luminous ray would reflect itself on a polished surface.

Is the problem of light refraction, the physical change which occurs in a light ray entering into a different medium, of a similar nature? What is the shortest path taken by a light ray travelling from a lighter medium, the air, into a denser medium of water or glass? What is the angle of refraction of the light ray as it enters the new medium?

If we proceed in exactly the same way as in the problem of light reflection, establishing a straight line from the point of departure of the ray in the air to the point of its arrival in the water or glass, we see clearly that this is not a least action path: By travelling the same distance in the water or glass (the denser medium) as in the air, the ray's progression is not the easiest (Figure 5). Fermat elaborated the hypothesis that, in order to take the path of least effort, the light ray will remain as long as it can in the air before entering into the water or glass. In so

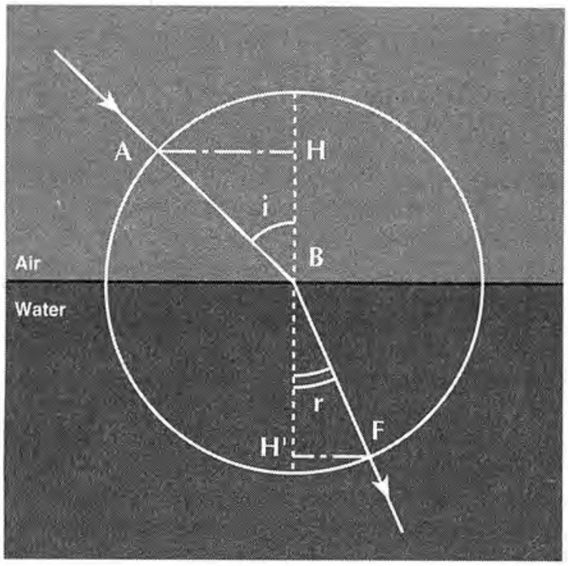


Figure 6
THE LAW OF SINUS

In his Optics, *Descartes delivers what is known as his Law of Sinus: "Whatever the angles of incidence and of refraction, the relation of their sinuses* AH/H′ F *in our figure, is always equal to the same constant when the light travels between two given mediums."* $N = \sin i / \sin r = n_1/n_2$*; thus* $n_1 \sin i = n_2 \sin r$*, where* n *corresponds to the refraction index of a given medium.*

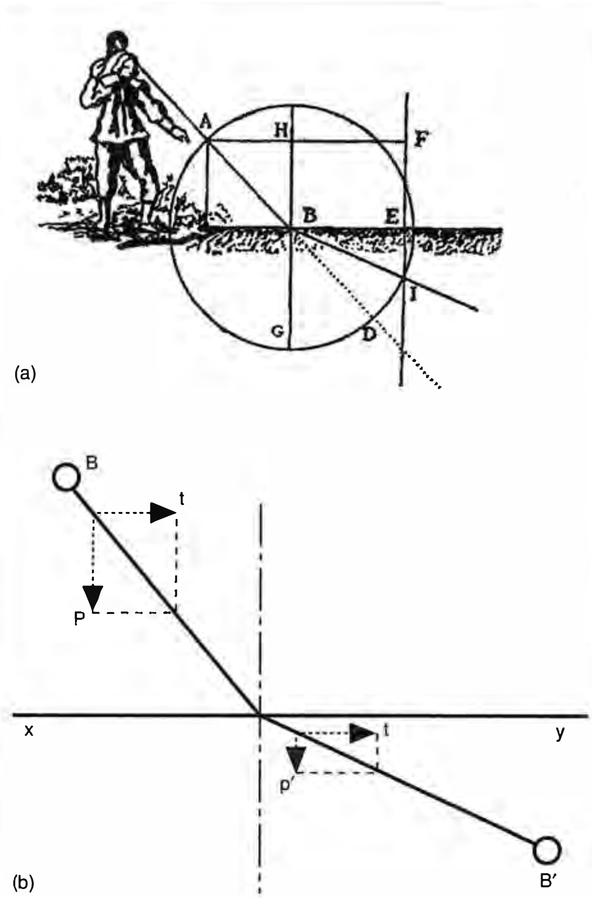


Figure 7
A SUSPICIOUS ERROR

This graphic (a), taken out of Descartes's Optics, *proves that Descartes stole his Sinus Law from Snellius. In fact, one can see clearly that coming into the water (the denser medium), the ray refracts toward* I, *moving away from the perpendicular. Yet, as one can see in Figure 5, in reality the ray comes closer to the perpendicular.* In *(b), Descartes considers the movement of the ball as the sum of two components (P* and *t). The resistance by a linen sheet or water surface diminishes only the perpendicular component (p′), leaving the other one (t) unchanged. It is the reason given by Descartes to explain why the ball crossing the sheet or surface would move away from the perpendicular.*

doing, it compensates for the longer total distance to travel by the fact that the longer displacement in the air actually costs it less, in terms of effort, than the shorter displacement in the water or in the glass. It is not the shortest distance that guides the ray but the least effort. Having elaborated this hypothesis, Fermat immediately applied his new minimum-maximum calculus to locate correctly the point of entry of a light ray going from an air to a glass medium.

This remarkable hypothesis raised, and continues to raise, strong controversy to this day. Why? Is not saying that light acts according to a least-action principle the same as saying that light intelligently organizes its travel plans? It appears as if the light had to decide at what point to turn into the water or glass, knowing from the start that it would be travelling through a second medium of higher density! In other words, ignoring the empiricists, who believe that the past determines the present and the future, the light here behaves as if its endpoint of arrival—the future—had determined, at each point, the present—the direction chosen by the light to travel! If we don't want to conclude that light is "intelligent" as such, we can adopt a more adequate explanation that the universe is organized in the most perfect of all possible ways, and that all the processes which take part in it reflect, in a conscious or an unconscious manner, this perfection.

Lacking the coherence of judgment shown by Fermat, Descartes's method is, to say the least, dubious: He presents correct calculations for his Sinus law (Figure 6), but the demonstration of his "discovery" in his *Optics* runs totally contrary to his own results!

If one examines Descartes's own graphics and explanations in *Optics,* one easily sees that it is not through this reasoning that he discovered the laws of refraction. Descartes claims that his starting point for defining reflection and refraction is the physical nature of light. Light is for him a phenomenon whose origin is the pressure exerted on the eye by the highly volatile matter rotating in the vortices. The Sun and other stars contribute to this phenomenon, which transmits itself through pressure, first through the subtle fluid between the planets, and then through the layers of air making up the atmosphere. All light and heat sources are for him of a mechanical nature—the flame is formed by invisible particles moving at a very fast speed, lacerating everything they touch, and provoking thus the effects of heat and of light.

Starting from these grounds, Descartes compares the reflection of a light ray to the bouncing of a ball from a wall. He then compares the refraction of light to the action of a ball puncturing a thin linen sheet, which, in his mind, is comparable to a ray moving from a lighter to a denser medium. He then reaches surprising conclusions, proving that he must have "borrowed" his Sinus law from somebody else. Indeed, Descartes tells us that in crossing the sheet, the ball loses half its speed in moving away from the perpendicular to the sheet—Figure 7(a).

Applying the image of the ball to the light ray crossing into the denser medium, Descartes says:

> Now let us suppose that the ball coming from *A* towards *D* does not strike a sheet at point *B*, but rather a body of water, the surface of which reduces its speed by exactly a half, as did the sheet. The other conditions being given as before, I say that this ball must pass from *B* in a straight line not towards *D*, but towards *I*. For, in the first place, it is certain that the surface of the water must deflect it towards that point in the same way as the sheet, seeing that it reduces the force of the ball by the same amount, and that it is opposed to the ball in the same direction. . . . And we may note here that the deflection of the ball by the surface of the water or the sheet is greater, the more oblique the angle at which it encounters it, so that if it encounters it at a right angle (as when it is impelled from *H* towards *B*) it must pass beyond in a straight line towards *G* without being deflected at all.[17]

Descartes explains that the direction of the motion of the ball must be considered to be the resultant of two components, one parallel and one perpendicular to the surface of the water. The resistance offered by the surface will diminish only the perpendicular component, leaving the other one unchanged. Thus, he believes, the ball crossing through the water would move away from the perpendicular toward *I*—Figure 7(b). In the real world, however, as opposed to Descartes's analogy, the light ray moves away from the perpendicular only when it crosses over from a medium of higher density to one of lower density. The explanations given by Descartes are accompanied by his graphics, which fully confirm that he believed that the ray moved away from the perpendicular, while in reality it comes closer to it. Descartes probably mistook for refraction the *trompe l'oeil* effect of introducing a stick into water, in which one indeed gets the impression that the stick breaks and projects its image toward the surface.

In one of his letters, Fermat denounced Descartes's fraud:

> The demonstration of refraction [by Descartes] appears as a true paralogism, first of all because Descartes bases it on a comparison and that geometry does not appreciate such figures . . . secondly because it supposes that the movement of light in the air or in the rarer bodies is slower than in the water or in the other bodies, something which is shocking to common sense.[18]

Leibniz is as critical in his *Discourse on Metaphysics:*

> It seems to me that Snellius, who was the first discoverer of the laws of refraction would have waited a long time before finding them if he had wished to seek out first how light was formed. But he apparently followed that method which the ancients employed for Catoptrics, that is, the method of final causes. . . . This principle Mons. Snellius, I believe, and afterwards independently of him, M. Fermat, applied most ingeniously to refraction. For since the rays, while in the same media always maintain the same proportion of sines, which in turn corresponds to the resistance of the media, it appears that they follow the easiest way. . . . That demonstration of this same theorem which M. Descartes has given, using efficient causes, is much less satisfactory. At least we have grounds to think that he would never have found the principle by that means if he had not learned in Holland of the discovery of Snellius.[19]

Is Motion Conserved in the Universe?

The conservation of motion in the universe is the other question which arises from a methodological problem, and shows all the inadequacy of Descartes's approach. Descartes believed, as mentioned above, that before going to sleep, God had set the universe in motion, a motion which it would conserve *Ad Vitam Eternum.* This idea is at the very heart of Cartesian mechanism. In *Discourse on Metaphysics,* Leibniz proves that it is not the quantity of motion that is constant, but the quantity of force. (Even though *force* is the word used by Leibniz himself, "power of transformation" might be a better expression of this idea today.)

To prove this, Leibniz takes two examples which the mathematicians of that time, including Descartes, particularly liked. He takes first the problem of two bodies which must be lifted: the body *A* weighing 1 pound which must be lifted to a height of 4 feet, and the body *B* weighing 4 pounds which must be lifted to a height of 1 foot. Leibniz says even the "new philosophers" will grant that the same force is required to lift both weights.

In Leibniz's second example he assumes two bodies falling freely in empty space (no friction) to bounce and lift themselves back to the same height from which each of them fell, like pendulums gathering the strength as they fall to lift themselves back to the departure point. There would be body *A* weighing 1 pound falling from a point 4 feet high, which would acquire enough force to bounce itself back to its departing point, and body B weighing 4 pounds falling from a point 1 foot high, which would gather enough force to bounce itself back to its departing point.

These two examples, the first which raises the question of the force necessary to lift the weights, and the second one, which poses the question of the force necessary for those weights to lift themselves to the point of departure, are supposed equivalent; that is, the force necessary to lift both weights is supposed to be the same.

Leibniz chose the second example, however, because it allows him to demonstrate that although the force remains the same, the quantity of motion (mass multiplied by velocity) is not conserved. There is conservation of force, but not of motion.

Leibniz explains from where this difference comes. As Galileo had shown, as a result of gravity, the speed of a freely falling body is subjected to a lesser or greater acceleration, proportional to the distance covered. (Distances covered are proportional to the square of the time of fall.) Leibniz reports that, following Galileo, the speed of body *A* weighing 1 pound and falling a distance of 4 feet, will be twice that of a body *B* weighing 4 pounds and falling a distance of 1 foot. Thus, the quantity of motion (mass × velocity) of body *A* will be $1 \times 2 = 2$; that of body *B* will be $4 \times 1 = 4$.

Not only is the quantity of motion not constant, but Leibniz introduces a concept of force that Descartes has not at all taken into account in his space-time, where he admits only extension, movement, figures, and the three dimensions.

This is what Leibniz concludes himself of the importance of this discovery:

> This consideration of the force, distinguished from the quantity of motion, is of importance, not only in physics and mechanics for finding the real laws of nature and the principles of motion, and even for correcting many practical errors which have crept into the writings of certain able mathematicians, but also in metaphysics it is of importance for the better understanding of principles. Because motion, if we regard only its exact and formal meaning, that is, change of place, is not something entirely real, and when several bodies change their places reciprocally, it is not possible to determine by considering the bodies alone to which among them movement or repose is to be attributed, as I could demonstrate geometrically, if I wished to stop for it now. But the force, or the proximate cause of these changes is something more real, and there are sufficient grounds for attributing it to one body rather than to another, and it is only through this latter investigation that we can determine to which one the movement must appertain. Now this force is something different from size, from form or from motion, and it can be seen from this consideration that the whole meaning of a body is not exhausted in its extension together with its modifications as our moderns [Descartes] persuade themselves. We are therefore obliged to restore certain beings or forms which they have banished. It appears more and more clear that although all the particular phenomena of nature can be explained mathematically or mechanically by those who understand them, yet nevertheless, the general principles of corporeal nature and even of mechanics are metaphysical rather than geometric, and belong rather to certain indivisible forms or natures as the causes of the appearances, than to the corporeal mass or to extension. This reflection is able to reconcile the mechanical philosophy of the moderns with the circumspection of those intelligent and well-meaning persons who, with a certain justice, fear that we are becoming too far removed from immaterial beings and that we are thus prejudicing piety.[20]

A mathematician Descartes will remain all his life. It is the only domain where, by the way, nobody contests his contributions: modern algebraic notation is from him, and he is credited, along with Fermat, with having laid the foundations of analytical geometry. Both of them, it is said, recognized at the same time that a given equation of two unknowns can be considered as the determination of a plane curve on a coordinate system (even though neither one was the creator of a coordinate-system geometry as such).

However, the two men were not looking for the same thing: Descartes wanted to make algebraic or linearize geometrical language, while Fermat was attempting, on the contrary, to better understand the physical properties of curves. Astonishingly for a mathematician whose pretensions were considerable, Descartes did not involve himself in the more difficult problems of the mathematics of his time. Refusing to take the infinite into account, and therefore, any idea of a transcendental projected onto the universe, Descartes avoided the more complex numbers, incommensurables and transcendentals. His geometry excludes the complex curves that the Greeks classified in the "linear" domain—the spirals, tractrixes, and others of the same type—because they are incommensurable. For the same reason, Descartes rejects the 12-tone logarithmic division of the musical scale, in favor of the natural scale of whole numbers.

Descartes: A Jesuit in Short Pants?

Now that we have reviewed the philosophy of Descartes, we must say something about the man and his role in history. This is perhaps the most interesting aspect of his life, but the one of which the least is known. In-depth research needs to be done in certain directions that we can only outline here.

Was Descartes only a philosopher, as his main biographers claim, or was he active in politics? Many aspects of his life point in the direction of the second hypothesis; for example, his presence between 1619 and 1628, as a volunteer in the armies of the allies of the Kings of France, in some of the main war theaters where the destiny of Europe was being decided at that time. The story goes, that it is in order to get to know the men and the princely courts, that Descartes joined the army.

In 1618, he joined the armies of Prince Maurice of Nassau, in Holland, who was at war with Spain, but also against what remained in Holland of the republican current of William I the Silent, regrouped around Oldenbarneveld. From there he joined the armies of Maximilian, the Duke of Bavaria, in a conflict opposing the Emperor Ferdinand, Maximilian, the Duke of Bavaria, and others to the Protestants assembled around the King of Bohemia and the Palatine Elector. The legend says that Descartes was only an observer. But this is particularly false in this conflict, where Descartes fought side by side with the Catholic party and that of the Emperor. He was so much involved, that after the victory of the Duke of Bavaria, he joined the party which continued the fight against the Protestants in Moravia. During this conflict, Descartes became the hated figure of the Protestants, who had nicknamed him the "Jesuit in short pants"! Later, as he was going to Italy, he managed to become interested in the conflict over Valteline, a territory of the Griffons allied to the King of France, that the Empire had just taken by force in favor of Spain.

What exactly was Descartes doing in those trips? This is what we should try to reconstruct. The main obstacle to developing new insights into his life would be to give too much credibility to the biography authored by André Baillet, at the end of the 17th century.[21] Baillet knew Descartes, and his very long and detailed biography has become a real "bible," which nobody really dares to contest. Yet, it is he who claims that Descartes carried out all these military deployments solely for the disinterested love of knowledge, while any astute investigator would have been led to formulate the hypothesis that Descartes had played an important role in secret diplomacy.

In this context, one should also strive to know more about his relations to the powerful Jesuits, who, at the very heart of the Catholic party at that time, represented and promoted with fanaticism the interests of the blackest of the oligarchies. There is no factional struggle, no war in Europe, no murder of kings, in this period, in which those defenders of the established order were not involved. Descartes was still a student of the Jesuits when Ravaillac lifted his knife against the King of France, Henry IV.

Shortly after Descartes's birth in 1596, the Society of Jesus reconstituted itself in France. Forced to compromise with the Catholic party, Henry IV married Marie de Médicis in 1600. That marriage obliged him, in 1604, to bring to an end the interdiction of the activities of the Jesuit Order in France. With the help of the King, the Jesuits then created the Royal Jesuit College de la Flèche at Anjou, destined to educate the nation's elite and turn it into the most brilliant of Europe. The Jesuits deployed great zeal in choosing the personnel and the teachers of this new school.


The Granger Collection

The Jesuit Pére Marin Mersenne (1588-1648), a mathematician, met Descartes when he was a student, and later put him in contact with the leading scientists of Europe.

It is here that between 1606 and 1614, Descartes was educated, apparently one of the best pupils of the school. According to some sources, Descartes and Père Marin Mersenne, the man who would later bring Descartes into correspondence with all the great scientists of his time, met at La Flèche, where Mersenne also studied. Here, also, Descartes learned the art of Scholasticism through in-depth studies of Aristotle and St. Thomas Aquinas, and of François Vieta's algebra.

Important for further research into the relations between Descartes and the Jesuits, is the fact that Father Charlet, a remote relative of Descartes, and Dean of the College de la Flèche while Descartes studied there, later became an important figure in the Society, a close assistant of the General of the Order in Rome. Throughout his life, Descartes remained in contact with Charlet. Although some claim that Descartes's relations with the Church were bad, when he published his *Principles of Philosophy* in 1644, five years before his death, his greatest wish was that the book would become a school manual to be used in the schools of the Society of Jesus.

Beyond those historical facts, it is Descartes's attitude toward other scientists that does not fit with that of a man motivated by love for knowledge. Beyond the fact that he was accused several times of having plagiarized others, his attitude toward other scientists was horrendous, oscillating between vanity and pedantry. Never does Descartes quote the names of other scientists or wise men from whom he borrowed amply, such as Kepler. His disdainful attitude toward Fermat, a scientist of great modesty who didn't publish while alive, in spite of his many contributions, illustrates better than anything else Descartes's despicable attitude toward knowledge. Following a harsh polemic, which opposed Fermat to Descartes after the publication of the latter's *La Géométrie (The Geometry),* and in spite of multiple efforts to reestablish peace between the two, Descartes persisted in never calling Fermat by name but only by a disdainful "your de Minimus/Maximus advisor." "All advisers, and Presidents, and great Geometres that those Misters might be, their objections and arguments are not defensible, and their mistakes are as clear as to say that two and two are four,"[22] wrote Descartes, who refused to grant any credit to Fermat or any other scientist whom he viewed as his rival.

Neither is Descartes's attitude toward the established powers one of a scientist using his knowledge for the general progress of the people. Contrary to what anybody might imagine, Descartes was never part of the revolutionary camp, but always firmly a part of the established order. The moral rules he lays out in his *Discourse on the Method* are clear on that point. He does not ask people to act according to truth, but to follow his example and "obey the laws and the customs of my country, constantly holding on to the religion in which God has given me the grace to be instructed from my childhood. . . ."[23]

Prudent but not wise, Descartes advises people to take a middle-of-the-road position, allowing them to change sides rapidly if they realize they're wrong:

> And, among several opinions equally accepted, I chose only the most moderate ones: as much because these are always the most commodious for praxis, and probably the best, all excess usually being bad; as also in order for me to detour less from the true path, in case I were to fail, than if, having chosen one of the extremes, it would have been the other that it would have been necessary to follow.[24]

Willebrod Snellius
1591-1626

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Pierre de Fermat
1601-1665

Willebrod Snellius (left), the Dutch astronomer and mathematician, and Pierre de Fermat, the greatest mathematician of his time, according to Pascal, discovered the laws of light refraction. Leibniz, Fermat, and others were even persuaded that Descartes had plagiarized Snellius, who, just before dying in Holland in 1625, had transmitted his discovery to Descartes.

Finally, Descartes calls on people to accept the established order and not to try to change it: "My third maxim was to try always to conquer rather myself than fortune, and to change rather my desires than the order of the world."[25] Descartes praises those philosophers who were happy despite sickness and poverty:

> For, incessantly occupying themselves with considering the limits that were prescribed to them by nature, they persuaded themselves so perfectly that nothing was within their power but their thoughts, that this alone was sufficient to prevent them from having any affection for other things.[26]

What a difference from a Leibniz, whose notion of morality derives directly from universal laws! Created in the image of God, man is the only creature which can understand Him and try to imitate Him. It is only in the act of transforming the universe for the Good, in trying to create a city of God on Earth in the image of His perfection, that men and women reflect the image of God and come closer to Him.

Other than a political role, Descartes succeeded especially in playing a role that occupied the intellectual scene, misleading many thinkers who would have naturally been attracted by the method of Pascal, of Fermat, and of Roberval, into imitating his fantasies and mathematical abstractions. In order to play that role, Descartes had to be credible in the scientific field. His close relationship to Mersenne put him into contact with the best of the scientific community of that time, keeping him informed of all the advances. His long trips to Holland are not uninteresting in this respect. In the aftermath of William I the Silent's revolt, the Low Countries had become the refuge for an important section of the European intellectual community. It is there that Snellius revealed to Descartes his discoveries on light refraction. It is there as volunteer in Prince Maurice of Nassau's army, that Descartes undoubtedly shared with Maurice the discoveries of Simon Stevin, who had tutored the Prince of Nassau. His volunteer engagements in the armies of the allies of the Kings of France also put him into contact with the corps of military engineers, always spearheading scientific discovery in those days.

Thanks to all those activities, Descartes was totally informed of the latest developments in the scientific field and seems often to have used this position to appropriate that knowledge.

The antinomic opposition of Descartes to British empiricism, his "I think, therefore I am," at opposite poles to their "I feel, therefore I am," reminds us strangely of the bipolarism which allowed Venice to control the world for so many years. Control two equally false, contrary options, and you control the world. One can very well imagine the enemies of the Renaissance, those who wanted to stop men from putting education, science, and technology in the service of human progress, manipulating, at the same time, an "empiricist" option that reduces men to the level of mere sensuous beasts, and a "formal-logical" option that sterilizes them. Astute manipulators like the Jesuits, could have played on those opposite archetypes, which Friedrich Schiller called "the savages" and "the barbarians"—with the savages dominated by their passions and the barbarians by mental constructions, empty of emotions. Thus, thinkers would be channeled into one of two intellectual cul-de-sacs. While thinkers took sides in this heated, but totally sterile battle, the real scientists, those who, like Leibniz, had created the conditions for a true material, cultural, and political progress of human beings, were eliminated from the intellectual scene.

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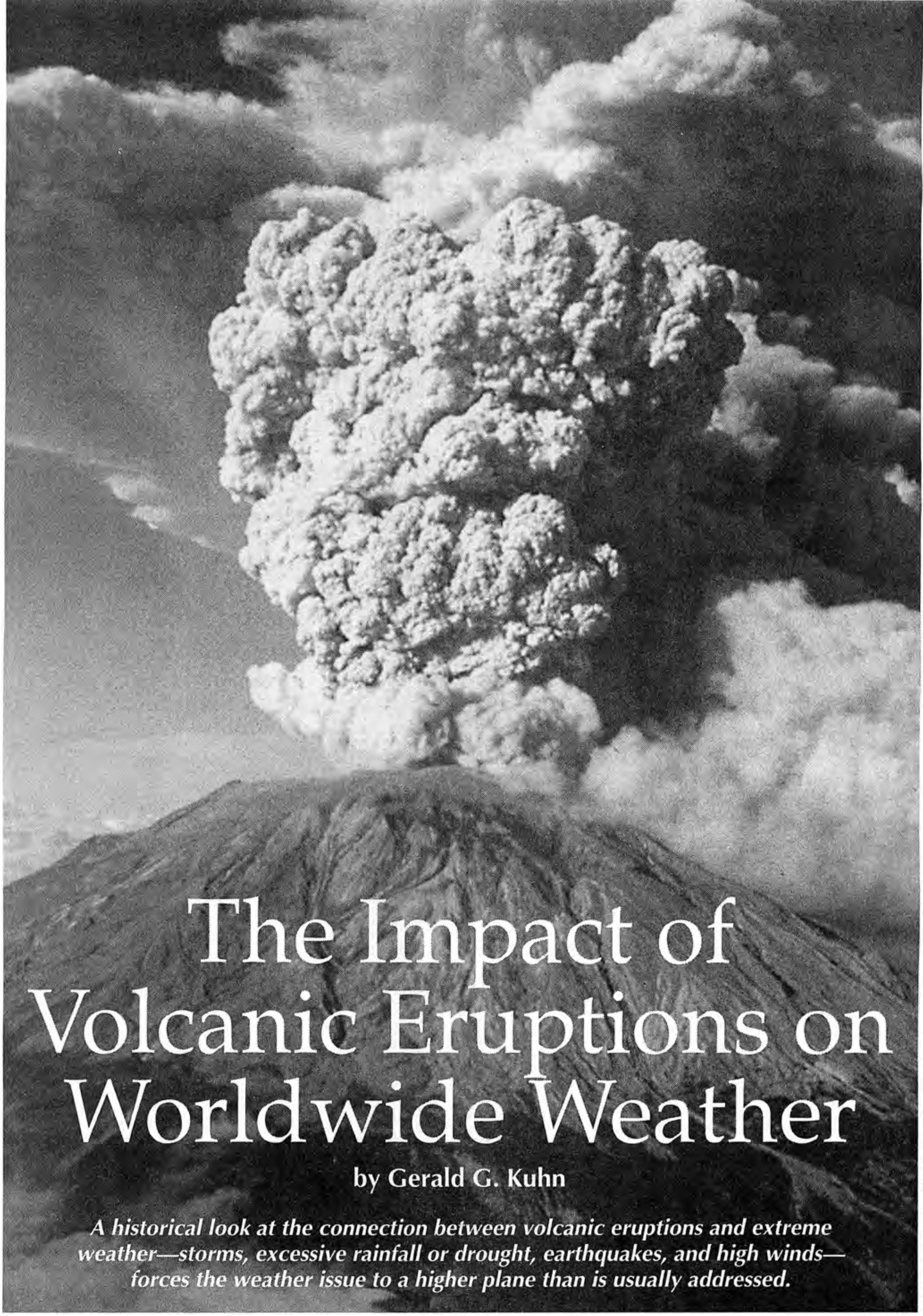
Notes

1. "The Essential Role of 'Time-Reversal' in Mathematical Economics, *Fidelio* magazine, Winter 1996; "On the Subject of God," *Fidelio,* Spring 1993.
2. Descartes, in the Preface to his *Principles of Philosophy,* made the same cry: "And I must also beg my readers never to attribute to me any opinion they do not find explicitly stated in my writings." *Principles of Philosophy,* p. 189. *In The Philosophical Writings of Descartes.* Translated by John Cottingham, Robert Stoothoff, and Dugald Murdoch (Cambridge: Cambridge University Press, 1985), Vol. I, pp. 177-291.
3. A Dutch translation was published in 1684.
4. René Descartes, *Rules for the Direction of the Mind,* Rule One, p. 9. *In* René Descartes, *The Philosophical Writings of Descartes.* See note 2.
5. *Rules,* Rule Two, p. 12.
6. *Rules,* Rule Three, p. 14.
7. *Rules,* Rule Two.
8. *Rules,* Rule Four, p. 16.
9. René Descartes, *Discours de la méthode pour bien conduire sa raison et chercher la verité dans les sciences (Discourse on the Method of Conducting One's Reason Well and of Seeking the Truth in the Sciences).* Translated by George Heffernan. (Notre Dame, Ind.: University of Notre Dame Press, 1994). p. 35.
10. In fact, Descartes says, "Indeed the best way of proving the falsity of Aristotle's principles is to point out that they have not enabled any progress to be made in all the centuries in which they have been followed." René Descartes, *Principles of Philosophy,* Preface, p.189. *In* René Descartes, *The Philosophical Writings of Descartes.* See note 2.
11. *Principles of Philosophy.*
12. *Discourse,* Paragraph 2, pp. 51-53.
13. *Principles,* Principle 26, pp. 201-202.
14. *Principles,* Principle 28, p. 202. In a French translation by Abbé Claude Picot in 1647, the phrases in brackets were added, possibly with the permission of Descartes.
15. Gottfried Wilhelm Leibniz, *The Monadology,* Paragraph 79, p. 269. *In* Gottfried Wilhelm Leibniz, *Discourse on Metaphysics; Correspondence with Arnauld; Monadology.* Translated by George Montgomery. (La Salle, Ill.: Open Court, 1902). Pp. 251-272.
16. *Principles,* Principle 30, pp. 253-254.
17. René Descartes, *Optics,* pp.159-160. *In* René Descartes, *The Philosophical Writings of Descartes.* See note 2.
18. P. Fermat, "Lettre à un destinaire inconnu," in *Varia Opera Mathematiqua D. Petri de Fermat (Toulouse, 1679)*
19. Gottfried Wilhelm Leibniz, *Discourse on Metaphysics,* Paragraph XXII, pp. 38-39. *In* Gottfried Wilhelm Leibniz, *Discourse on Metaphysics; Correspondence with Arnauld; Monadology.* See note 15.
20. Leibniz, *Discourse on Metaphysics,* Paragraph XVIII, pp. 32-33.
21. A. Baillet, *La vie de Monsieur Des Cartes* (Paris, 1691).
22. Descartes Lettres III, p. 189.
23. *Discourse,* p. 41.
24. *Discourse,* p. 41.
25. *Discourse,* p. 43.
26. *Discourse,* p. 45.



The Impact of Volcanic Eruptions on Worldwide Weather

by Gerald G. Kuhn

A historical look at the connection between volcanic eruptions and extreme weather—storms, excessive rainfall or drought, earthquakes, and high winds—forces the weather issue to a higher plane than is usually addressed.

M.P. Doudas, U.S. Geological Survey

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This article is a condensed version of a comprehensive work in preparation, and summarizes the basic concepts developed by Kuhn and Shepard.

Since the time of Benjamin Franklin, scientists have considered that volcanism might be important in producing weather changes, mainly because of the temperature modifications caused by explosive eruptions, from which quantities of material are injected into the upper troposphere and stratosphere. In the past few years, it has been documented that it is not the quantity of ash and gas thrown into the atmosphere, but rather the *quality* of the gases, that is important. The gases, as aerosols, diminish the heat from the Sun, thereby affecting weather and climate. This is especially the case for ejected sulfur dioxide in the stratosphere, where the minute aerosol globules form a distinct blanketing layer.

The climatologist Hubert Lamb presented the empirical evidence for a volcano and climate connection in 1970, in a study that has become a classic. Lamb created the Volcanic dust veil index (DVI), based upon a chronology of important volcanic eruptions after the year 1500. He defined the volcanic DVI as an estimate of fine dust, or ash, ejected into the upper atmosphere during specific eruptions. Lamb also suggested that sulfur-rich eruptions affected climate, when they reach the stratosphere. Other indices were subsequently created based on eruption volume, and volcanic explosivity. The latter is called the Volcanic Explosivity Index (VEI), and is based upon estimates of explosive energy with eruption volume, as documented by the height of the eruption plume.

Ben Franklin: 'Father of Volcano Weather'

In 1785, Benjamin Franklin, representing the new American nation at the French court, noted that the great cold and universal dry "fog" that prevailed across Europe and North America in the years of 1784-1785, must have been related to volcanic eruptions of Laki, reported in Iceland in 1783. According to Franklin, the fog must have caused a decline in the surface temperature by absorbing some of the incident sunlight, thereby reducing the amount that reached the Earth's surface.

Franklin suggested in a memo to the Royal Academy that in view of this universal fog,

> it seems worth the inquiry, whether other hard winters recorded in history, were preceded by similar permanent and widely extended summer fogs. Because if found to be so, men might from such fogs, conjecture and learn the probability of a succeeding hard winter . . . and take such measures as are possible or practicable to secure themselves and effects from the mischief that attended the last."

Mt. St. Helens, Washington state, erupting on July 22, 1980.

Because of his observations and analysis, scientists have honored Franklin as the "Father of Volcano Weather."

A century after Franklin, the Krakatoa Commission of the Royal Society of London, in a now classic study, established the connection between major volcanic eruptions and worldwide changes in atmospheric optical properties, as noted after the giant eruption of Krakatau in August 1883. And a century after that, the climatologist Lamb estimated that major eruptions in Iceland and Japan during 1783 may have caused an overall global cooling of the Northern Hemisphere by 1.3°C, although, as Lamb noted, this temperature decrease may have ceased after one or two decades.

More recent evidence of such cooling following volcanic eruption can be learned in the work of Henry and Elizabeth Stommel, of the Woods Hole Oceanographic Institution. The Stommels show that after the tremendous eruption of the Indonesian volcano, Tambora, in 1815, there was a period of cold weather in the summer of 1816 in New England, which ruined most of the crops, as a result of heavy frosts and unseasonable snowstorms. There were similar effects in Great Britain and in some parts of Western Europe, while much of Eastern Europe was abnormally wet, causing the loss of the grape harvests. At the same time, high latitude Russia warmed, which enabled that country to feed much of the Western world for years with grain grown on the steppes of Russia. In the United States, southern California exited a prolonged drought period and entered a subtropical rain regime, which increased the grain yields of corn, barley, and wheat grown at all the southern California Missions.

Is Sulfur the Key?

Prior to the 1960s, scientists believed that volcanic ash injected into the stratosphere was the most important cause of climate fluctuations. In 1961, Christian Junge discovered, however, the existence of a volcanic aerosol layer (mainly of tiny sulfuric acid droplets), readily sampled from an aircraft in the uppermost troposphere, at around 16 miles. Such high-altitude aerosols affect the heat budget of the atmosphere: Incoming solar radiation is reflected, scattered, deflected, and absorbed by the aerosols. Back-scattering and absorption of solar radiation may then cause cooling of the Earth's surface and lower atmosphere, as documented after the eruption of Katmai in 1912, and after previous eruptions.

In 1974, Castleman and others indicated that the majority of the sulfate aerosols in the "layer" were volcanic in origin, and that its very existence depended on how often volcanic eruptions penetrated the tropopause. The stratosphere apparently remains clear and free of sulfuric acid globules during periods of volcanic inactivity, but may become rapidly contaminated during sulfur-rich eruptions, such as those of Mt. Pinatubo in 1991, and El Chichon in 1982.

What scientists discovered in the 1980s, is that relatively small volcanic eruptions, such as that of Mt. Agung in 1963 or El Chichon in 1982, could have atmospheric effects similar to those of the larger eruptions of Tambora in 1815 or Krakatau in 1883, because they released such large concentrations of sulfur dioxide (SO_2), hydrogen sulfide (H_2S), and other sulfur-rich volatiles into the stratosphere. Researchers Rampino and Self have indicated that the comparison of data from direct measurements of stratospheric optical depth, Greenland ice-core acidity and volcanological studies shows that such relatively small, but sulfur-rich, eruptions can have effects equal to or greater than much larger sulfur-poor eruptions.

In a 1988 article, Rampino et al. state:

> It was clear that the composition of the volcanic ejecta, particularly the amount of sulfur volatiles released, had an importance above and beyond that of the total amount of ash ejected. The geographic location, time of year, and prevailing climatic conditions (for example, phase in the quasi-biennial oscillation cycle) were also seen to be critical factors in determining the spread and lifetime of volcanic aerosol clouds.

Measuring Volcanic Gases

There are four principal methods for determining the amount and composition of volcanic gases that are produced during large volcanic eruptions: examining the composition and amount of those acids in polar ice core aerosol layers that can be confirmed to have been related to volcanic eruptions; combining estimates of the mass of volcanic magma with the chemical analyses of the glasses and minerals in the volcanic rocks; satellite measurements; and technologies such as LIDAR (light detection and ranging), to measure gases from the Earth's surface.

Volcanic acid estimates recorded in ice-cores. The Danish chemist C.U. Hammer was the first to use acid layers in ice cores to determine a precise record of past volcanic activity, and he was able to date volcanic eruptions to the nearest year between the 12th century and 1970. Hammer and his co-workers made an important correlation between volcanism and climate, when they were examining annual layers in a mid-Greenland ice core, accurately dating them to within three years, back to the year 553. They compared various climate records with periods of frequent and explosive eruptions, and suggested a correlation which coincided with cold climatic conditions: The "highest volcanic activities since 553 occurred in the years 1250-1500 and 1550-1700, that is, in the initial and the culminating phases of the Little Ice Age."

Volcanic glass inclusion estimates of volcanic gases. Geologists have attempted to calculate the yield of gases from volcanic eruptions by analyzing glass inclusions in crystals which formed in volcanic rocks before the eruptions occurred. At the American Geophysical Union Chapman conference held at Hilo, Hawaii, in 1992, Sigurdsson, Westrich, and Gerlach presented their preliminary results on gases (sulfur) identified in volcanic rock inclusions from the Mount Pinatubo volcano. They indicated that the method needed refinement by further research and cross-checking with other methods such as ice cores and satellite observations.

Satellite monitoring of volcanic eruptions. Satellites have been used to monitor large eruptions of volcanoes since the late 1970s. Distinguishing between clouds and volcanic eruptions presented some problems in the early days, but recent refinement of the Total Ozone Mapping Spectrometer (TOMS) on the Nimbus-7 satellite has enabled the satellite to map not only the amount of ozone in the Earth's atmosphere, but also sulfur dioxide volcanic clouds. In 1983, Arlin Krueger indicated that the TOMS instrument on the Nimbus-7 satellite observed the eruptions of El Chichon in the Yucatan, Mexico, on March 28 and April 3-4, 1982. Ultraviolet pictures measured the volume, drift, and dispersion of the volcanic gas clouds, and determined that the gas measured was sulfur dioxide and not the global total ozone. Each of the major El Chichon eruptions produced clouds that were discernible, and a preliminary estimate of the mass of sulfur dioxide deposited in the stratosphere was approximately 3.3 megatons.

This study was important, as prior estimates of volcanic cloud volume were based on extrapolation of locally measured sulfur dioxide concentrations. Then in 1991, the TOMS satellite measured approximately 20 megatons of sulfur dioxide from the Mount Pinatubo eruptions of June 1991, possibly the largest amount of sulfur volatiles of the 20th century.

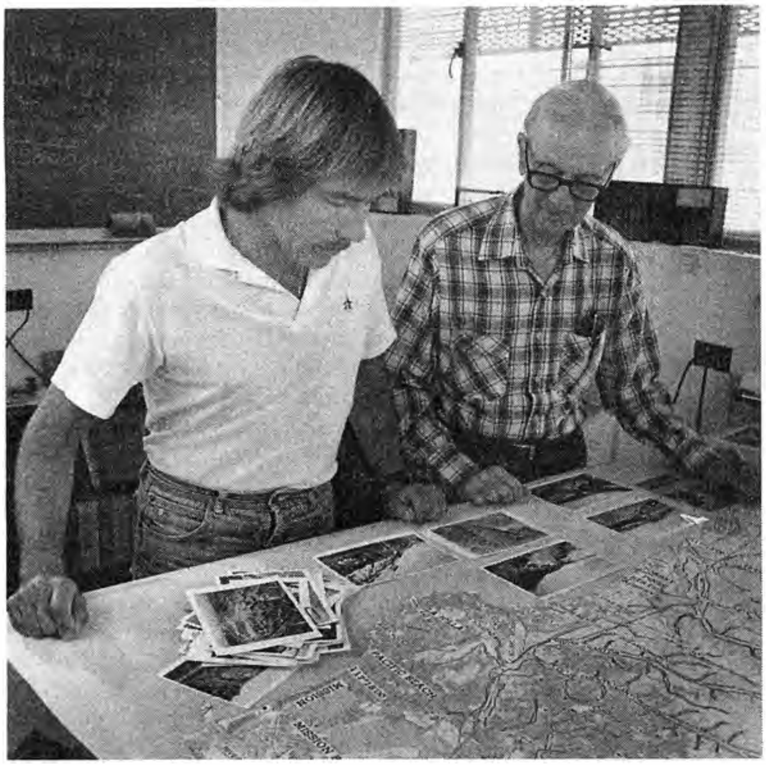
Measuring volcanic aerosols from the Earth's surface. Aerosol clouds and layers can also be monitored from the ground. Great "dry fogs" and "hazes" were studied by astronomers and other scientists in 1912, following the eruptions of Katmai at Novaruptu in Alaska. Changes in the measurements of solar radiation as a result of the "dry fog" or "haze" were detected worldwide, and the haze prevented clear observations of stars and planets. As mentioned above, Benjamin Franklin observed the dry fog in 1785, following the eruption of Laki in Iceland.

In more recent volcanic periods, namely Agung (1963), El Chichon (1982), and Pinatubo (1991), scientists have utilized new techniques and instruments to monitor and estimate sulfur dioxide aerosols from volcanic eruptions. One of these, used by some observatories, is called LIDAR or light detection and ranging. This laser instrument sends a pulsing light beam into the air, which reflects back when it encounters aerosols, thus providing a vertical profile of the density and height of volcanic aerosols.

The Evidence from Weather Records

Marine geologist Francis Shepard and I began our work 20 years ago, initially investigating the history of storms and various types of anomalous winds, such as severe tornadoes, hurricanes, typhoons, cyclones, and other great wind storms. We were looking at severe weather, to find out if these conditions might be repeated in the future, and what effect they might have on coastal erosion. (Strong onshore winds and large waves greatly accelerate coastal erosion.) Shepard had started this research in the 1930s, along with geologist Ulysses S. Grant IV, the grandson of the President, trying to find out whether California's stormy weather was episodic.

Originally, we and others were looking at the varves (marine layers) in the Santa Barbara basin off the coast of California, to see how thick they were, and from that to estimate how heavy the rainfall was on land that washed the matter into the sea. The Santa Barbara basin is for the most part oxygen-poor—anaerobic—so nothing thrives very well. But we found that from 1835 to 1839, there was a major change, a complete overturning in the water column, and the Santa Barbara basin became oxygen-rich. This was verified by a number of scientists who looked at 59 ocean cores, and found one species that



Scripps Institution of Oceanography

The author (left) with Francis Shepard, at the Scripps Institution of Oceanography in 1984.

had been alive in the period 1835-1839. This was a surprise, because scientists had assumed that the basin had never been oxygen-rich and able to support life.

The other mystery of this period is that in the 1830s, the Black Sea appears to have overturned, bringing sedimentary materials and anaerobic waters from the bottom to the surface. So here were two large bodies of water, in different parts of the world, which seemed to be affected by some large event at that time.

We looked at these data, along with the historical data from tree rings, and the changes in the fish stocks (one of the other mysteries of that period, is why the anchovies and the sardines left the coast of southern California, and why one species disappeared). We also looked at whether the water during that period was warm or cold, and how much land was washed out to sea by these storms.

This was a period in which there were dramatic changes in the weather; these were the years about which the naturalist Richard Henry Dana wrote the classic, *Two Years Before the Mast.* In 1834, for example, ship captains dreaded the trip around Cape Horn; there were nothing but tremendous seas. Then, from 1835 on, that area was becalmed. But, from 1835 to 1839, mariners along the coast of California were warned by the U.S. Coast and Geodetic Survey, to stay three miles beyond the shore between November and April, to have extra sliplines on their capstans in order to dump their anchors and run to sea, because of the great so'easters that came up. These were often storms that would last two weeks, with waves 50 to 60 feet high. We thought that this very stormy episode may have been related to the eruption of Cosequina in Nicaragua on Jan. 21, 1835, along with the eruption of most of the volcanoes of southern Chile, on Feb. 21 of the same year.

From the historical tree ring studies, we know that the 1830s were a period of extremely cold water, with no warm water events. During this period, the storms stopped in 1840, until about 1844, and picked up again in about 1845; in 1861-1862, there was the largest storm of the last century, so large that it was called the Noachian deluge, after Noah.

These 1860s storms coincided with extraordinary volcanic activity and plumes that reached the stratosphere. This was the key. No one knew at the time if these eruptions were sulfur rich or not; at that time, it was thought simply that volcanic dust altered the sunlight hitting the Earth, and thus cooled the planet.

The 1861-1862 deluge could be a book in itself, and puts contemporary flooding events in perspective: The storms which began on Jan. 31, 1861, and went into March 1862, bankrupted the state of California. There were 8 1/2 feet of rain—102 inches fell in 44 days in northern California. A series of storms came out of the north and laid down great snow packs in the Sierras; another series of storms came out of the south, and they alternated back and forth.

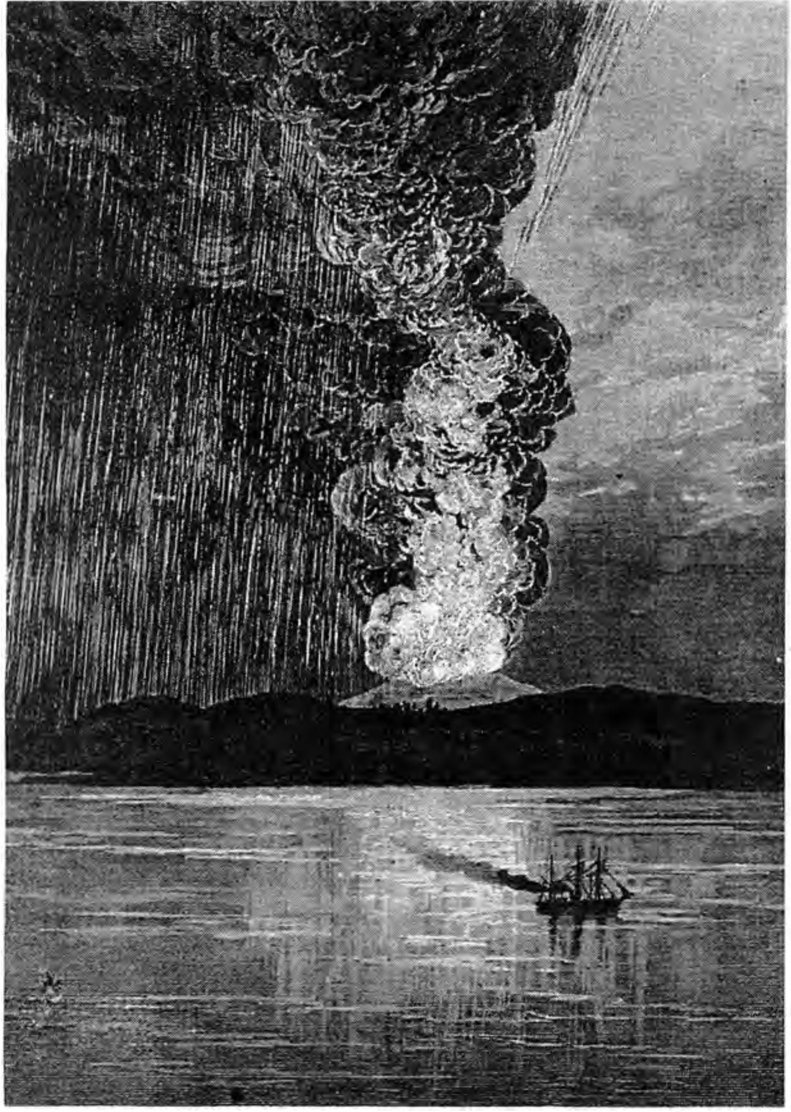
The great valley of the Sacramento and the San Joaquin filled with water. It was a vast lake, 30 to 60 miles wide, as much as 200 miles long. All of this was verified in the diary of geologist William H. Brewer, titled "Up and Down California, 1862-64." Brewer, who became the first geologist of the State of California, was a professor of agriculture, who was asked to study the resources of the state, and got caught in the floods. He rescued the California governor from the judge's mansion, which was the highest point above water in Sacramento, before it went under. The governor was taken by boat to San Francisco, where the legislature also had been removed by boat. The capital was moved to San Francisco for a year and a half, and all state employees were unpaid for that year and a half. One quarter of the taxable real estate of California was washed away.

The storms were not limited to California. In Arizona, the rivers (Colorado and Gila) at Yuma were 20 miles wide. The only thing left was the prison at Yuma, with an atheist major on the roof—praying. In Utah, the Mormon diaries of the time indicate that they were upset that so much of the state was under water. Nevada was cut off from the the rest of the western territories, as were Oregon, Washington, and Baja California, because of the great gullies that were cut during the rains. The Hawaiian Islands were battered with storms that lasted as long as a month. We know that there were vessels that left Hilo Harbor with a cargo of wood on board and actually had to use all the wood as fuel, just to get back.

The storms also passed to the East Coast. The diaries of U.S. Grant, then the Army commander-in-chief, for example, indicate that in February 1862, he had to call off all battles of the Civil War, because of the great "bog down."

In the Wake of Krakatau

During the course of this work, Shepard and I were impressed at finding that tremendous erosion took place on the



The Granger Collection

A contemporary line engraving of the Aug. 27, 1883, eruption of Krakatau, in the Sunda Strait, between Sumatra and Java. About two thirds of the island of Krakatau was blown away in the eruption.

weather in other, nearby areas.

In studying the significant volcanic episodes of the last century, for which there exist reliable government records, we learned that the periods after all of these eruptions included sudden changes from what might be considered normal weather conditions, to extremely abnormal conditions. We looked at all sorts of records from the period of historical metereological and storm conditions affecting southern California, in order to acquire a clearer understanding as to whether climatic fluctuations had been gradual, or very abrupt, during the period for which there are even proxy records.

Our research also clearly indicates that storm years of record have occurred after the significant *sulfur-rich* volcanic eruptions, whether or not a warm-water El Niño-Southern Oscillation episode was occurring, such as the great storm year of 1884.

Our studies of the weather records that followed all the great, explosive, sulfur-rich eruptions during the past, clearly indicated that extremely abnormal weather conditions existed in all cases, although these conditions varied somewhat for the different eruptions. The post-volcanic weather conditions were notable, both for the extraordinary weather modifications that took place, and for the unusually stormy conditions, which were almost continuous. Because these periods, for the most part, had very great rainfall, at least over much of the United States, they were usually followed by, or accompanied by record floods. In fact, most of the record floods of the last 120 years took place during these post-volcanic episodes.

There were also great wind storms. Tornadoes, which occurred at almost all periods during the last 120 years, were particularly abundant during these post-volcanic episodes. Hurricanes were also especially frequent during these post-volcanic periods, and, in fact, were abundant after the most recent eruptions of Mt. Pinatubo in 1991, when five record hurricanes (Andrew, Iniki, Omar, Forrest, and Bob), devastated coastal areas.

The weather changes were so extreme, that during the post-volcanic periods, seasons got displaced. It is common, for example, to have a "year without a summer." This happened four or five times, at least, during the different periods that we examined.

West Coast of the United States after the Aug. 27, 1883, sulfur-rich eruption of the island of Krakatau, which is one of the giants in the history of recent volcanism. Marine and inland erosion had greatly increased, after more than a decade of drought, and floods had become extremely important, particularly in southern California, where some of the most devastating for which there are records, took place in 1884, the year after the Krakatau eruption.

We then began a systematic study of the various records that existed for 1884. We also looked at books about storms, logs and diaries of mariners, and other scientific sources, in order to acquire all the historical information available concerning weather phenomena and atmospheric conditions that developed following the great eruption. This research indicated that, in most cases, within a very short time following the eruptions, starting with the Krakatau eruption, there was a tremendous increase in extreme stormy conditions—including hurricanes and tornadoes, and torrential rains that produced floods. At the same time, however, conditions in other parts of the world were quite the opposite—extreme aridity, and very cold weather in some places, along with exceptionally warm

A Case Study: The Eruptions of the Late 19th Century

The Krakatau Volcanic Period: 1883 to 1891

The eruption of the volcano complex, Krakatau, which was one of the greatest in history, took place Aug. 27, 1883. It ejected a tremendous mass of volcanic tephra and debris into the upper atmosphere, to a height of 50 km (30 miles), which circled repeatedly around the globe, and caused amazing sunsets, solar halos, and lunar effects for the next two years.

When the eruption occurred, a great mass of ocean water was displaced, which produced an immense tsunami that killed 36,000 people, and inundated vast areas near Java. The tsunami waves moved around the entire world, and were recorded on the tide gauge at the mouth of the Thames River in England, on the other side of the globe. A sound wave, after the eruption, was heard as far away as Madagascar, at a distance of almost 3,000 miles. Large amounts of fine ash and volatiles were dispersed into the the upper atmosphere, and subsequent research showed that the Krakatau eruption produced a cloud of approximately 50 megatons of sulfur dioxide aerosols.

Our research of archived weather records indicates that following the eruption, and during the fall of 1883, there was one month (October) when the weather became highly variable, from cooler than normal, to warmer than normal, for the nation. There were not very many floods reported and no abnormally strong winds were reported. Then, in January 1884, the weather began to change. There was record cold reported in portions of the United States and, as a whole, the nation was cooler than normal. These conditions continued for most of the United States through the following August.

During February 1884, all weather conditions increased: the general storminess, record tornadoes for the month, extreme high winds of hurricane force, record snow falls, unusually heavy rains, and record rainfalls in many places, and floods of record. The United States, itself, was markedly cool. During this same spectacular month, several of the southern states were devastated by very violent tornadoes. Depending on what source of information was examined, the tornadoes which touched down on Feb. 19, 1884, numbered from 40 to 60. They were most destructive in Georgia, Alabama, and the Carolinas, and caused great loss of life and property. More than $2 million (1884 dollars) in property was destroyed in Georgia alone. Three days before these large storms hit the southern states, causing these violent tornadoes, the first severe storms slammed into the coast of California.

During February and March 1884, southern California in general, and San Diego County, in particular, experienced one of the greatest flood periods of record, with 50 to 70 inches of rainfall. This rainfall of record that fell in the winter-spring of 1884 in the southwestern United States, was more than the total rainfall in the previous decade.

In 1884, another devastating flood was recorded on the Ohio River, which broke all years of record. During these months, the water also rose to extreme heights in many sections along the Mississippi River. The heights of this flood were not equalled again until the tremendous floods of 1983, which occurred during the El Chichon volcanic period, the stormiest period during the last hundred years.

The 1880s were not only a very stormy period, but one of extreme coastal retreat. It appears that the currents along the coast changed and erased sand bars, which would indicate a reversal of the current and storms entering the region from the south. Also, the substantial coastal erosion that occurred during this period, was recorded in railroad records, and substantiated by San Diego County tax records after the Krakatau event all the way up to about 1892. The California Southern Railroad, for example, was completely bankrupt in April 1884, because of the great floods.

The floods that were produced by the long-term heavy rains continued until October 1884. In the second winter after the Krakatau volcanic eruptions, pronounced cold waves occurred. It was reported by the U.S. Signal Service that

> the month [December] was unusually cold over the northwestern part of the United States, the departures below the normal temperature amounting to from 10°F to 23°F from Dakota westward to the Pacific. The weather was very severe during the last half of the month for Minnesota westward to the Pacific Coast, attended in Oregon and Washington territory by unusually heavy snowfalls, causing much loss of life and property.

January 1885 was colder than normal for most of the nation, with severe snowstorms reported in western and southern districts, which seriously interrupted all kinds of travel then available and inflicted heavy losses on livestock. Great tornadoes occurred on the 11th and 12th in the south. The U.S. Army Signal Service records for 1885 indicated that February "was colder than the average" in all districts east of the Rocky Mountains:

> In the Lake region and central valleys, the mean temperatures averaged from 10°F to 15°F below the normal. In the central Mississippi and Ohio valleys, in the Gulf States, and on the Atlantic coast south of New England, the mean temperatures were the lowest that have occurred since the establishment of the Signal Service stations.

At the same time, drought prevailed over most of the nation. By March, exceptional cold prevailed in the districts east of the Mississippi River and in the western Gulf states and South, except in Florida and Tennessee. Precipitation was deficient over nearly the entire nation. Even in April, spring was delayed several weeks from the Mississippi valley east. Cold weather was reported in the Midwest and East Coast during May and June, and it was unusually cool for the rest of the summer, but after that the conditions became quite normal; floods, tornadoes and heavy rains virtually ceased in August 1885. Apparently, the effects of the Krakatau eruption period had come to an end.

It should be noted that no apparent El Niño equatorial warming event occurred in 1883, although a strong El Niño event was reported in 1884. Scientists cored the annual varved layers of the anaerobic Santa Barbara Basin in 1994, and indicated that "the year 1884, one year after the eruption of Krakatau, was characterized by abnormal weather, but the oceanographic link to simultaneous South American El Niño in 1884 is uncertain." Further, the scientists stated: "We suggest that the postulated South American El Niño event of 1884 and its possible oceanographic repercussions on the Santa Barbara Basin may be related to, or even caused by, the Krakatau eruption."

Subsequent researchers concluded: "It now appears in retrospect that the relatively strong El Niño of 1883-1884 was likely intensified as a result of the volcanic dust from the eruption of Krakatau in August 1883. The fact that Krakatau is located adjacent to the Indonesian "Maritime Continent" further increases the likelihood that this region experienced the greatest insolation-reducing effects from the eruption.

The Bandai-San Eruption and the 1890s

The great eruption of Bandai-San, Japan, in July 1888 was the climax of a series of important eruptions that came in the wake of the great eruption of Krakatau in August 1883. Because there were several eruptions that preceded and followed the eruption of Bandai-San, and because of the exceptionally strong El Niño episode between 1889 and 1891, and especially the very strong El Niño-Southern Oscillation event of 1891, we investigated the entire period from 1886 to 1891.

There were no impressive weather changes until January 1890, after which an extraordinary series of weather events developed. In examining the reports of the U.S. Signal Service, beginning in January of 1890, we uncovered perhaps the most exceptional period of rapid and intense weather changes in all 125 years for which there are records. The *Monthly Weather Review* for this period showed that over the greater portion of the nation, east of the Mississippi River, the winter of 1889-1890 was the warmest on record.

For January 1890, the U.S. Signal Service weather records reported:

> On January 12th, destructive local storms occurred in the middle Mississippi and Ohio valleys. During the passage of a tornado over Saint Louis, Mo., three persons were killed and several were injured, and hundreds of houses were blown down or damaged. At Clifton, Ky., 10 persons were killed and about 50 were injured, and immense damage was caused to buildings. On this date a heavy snow storm with high wind and falling temperature, prevailed over Minnesota, the Dakotas, Nebraska, Kansas, and Iowa, and caused a general blockade of the railroads from Minnesota and the Dakotas southwestward over Kansas. On the 12th and 13th the storm along the lower [Great] Lakes and on Lake Huron was one of the severest in many years, and was attended by fatalities and great destruction of property. The heaviest snow blockade ever known on the Central Pacific Railroad occurred during the latter half of the month, when about 120 miles of the railroad crossing the summit of the Sierra Nevada Mountains was blockaded. In the northern counties of Nevada the excessive snowfall caused great loss of livestock. At stations in north Montana, north Nevada, and California, the month was the coldest January on record. In the early part of the month floods destroyed millions of dollars worth of property in south Missouri, east Arkansas, and north and east Texas. In the latter part of the month floods, resulting from melting snow, caused great damage in north California.

These uninterrupted, erratic, and extreme temperature changes continued right through May of 1890, as shown in the records of the U.S. Weather Bureau, Department of Agriculture, and the Army Signal Service. These reports for February-May by the U.S. Signal Service describe the weather extremes and the destruction wrought:

> February was the warmest February on record in the Atlantic coast and Gulf states, and in areas in the Ohio Valley and Tennessee. A cold wave the latter part of the month caused great loss of stock on the ranges in east Oregon and northeast Nevada. The great depth of snow in the cuts along the line of the Central Pacific Railroad crossing the summit of the Sierra Nevada Mountains caused serious interruption to the train service. Lakes Erie and Huron were reported practically open to navigation. Destructive floods occurred in west Oregon and north California in the early part of the month. The rivers were generally above the danger-line in the Ohio, Cumberland, Tennessee, and lower Mississippi valleys during the latter part of the month, and great damage was caused by the overflow of streams in Ohio and west Kentucky. The Verde and Gila Rivers, Ariz., overflowed their banks, and the large storage dam on the Hassayampa River, Ariz., gave way causing loss of life and destruction of property. . . .
>
> In March a great flood prevailed in the lower Mississippi Valley, and at most of the important points along the lower Mississippi river the water was the highest ever known. Flood conditions also prevailed along the Ohio River and its tributaries, and at the close of the month the rivers were above the danger line from Cincinnati, Ohio, to the Gulf of Mexico. On the 27th a group of destructive tornadoes occurred in Kentucky, south Indiana, south Illinois, and southeast Missouri. In Kentucky upwards of 100 lives were lost, and property to the value of about $4,000,000 [1890 dollars] was destroyed. . . . Cold waves of unprecedented seasonal severity swept over the southern and southeastern states during the first and middle parts of the month. . . .
>
> In April the great flood in the lower Mississippi continued. . . . At the close of the month not less than 15 parishes, or about one-fourth of the state of Louisiana, had been affected by the flood; about 10,000 acres had been inundated. . . .

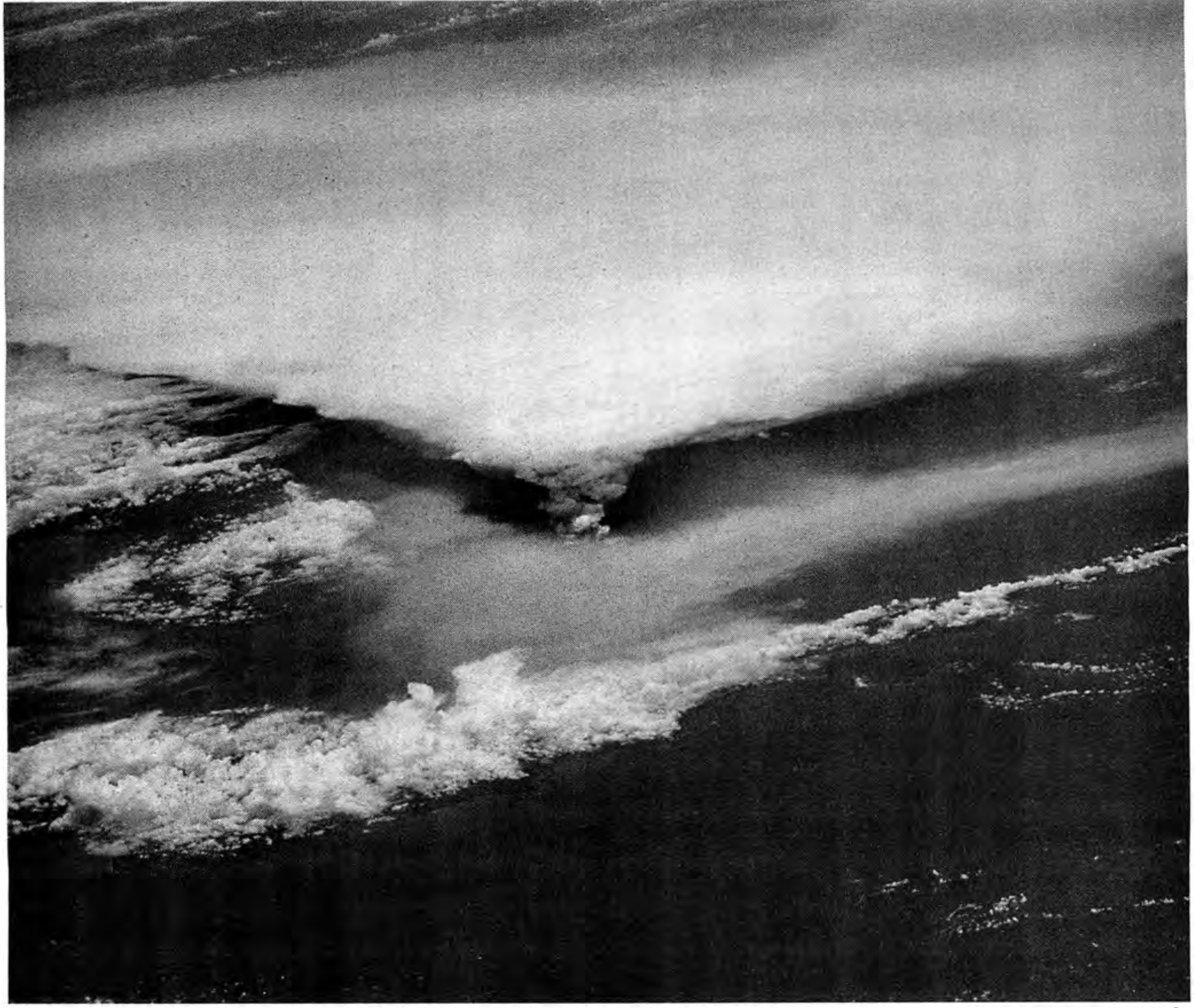
During July 1890, there were destructive tornadoes in Nebraska, Illinois, Minnesota, and Massachusetts (Lawrence). There was also damaging drought that prevailed in Kansas, Nebraska, and Iowa, and in areas in the Ohio Valley and Tennessee, the Lake region, and the Atlantic coast states from Massachusetts to Alabama.

In August, there was a severe cold wave, which advanced from the northwest over the central valleys west of the Mississippi, with unprecedented low temperatures for the season and early frost. At the same time, destructive floods prevailed in central western New York, central western Pennsylvania, West Virginia, Ohio, and Connecticut in the middle of the month.

The year of 1890 would go down in history as the most amazing time of great weather extremes and unusual conditions in all of our weather books. Of course, this is what might be expected, considering the large volcanic eruptions that were ejecting extraordinarily large amounts of ash and sulfur volatiles in the upper atmosphere at that time.

The 1912 Katmai Eruption

The case of the Katmai volcanic eruption in 1912 is particularly interesting, because there is good scientific reporting of its effects, and the effects were almost immediate. On June 6, 1912, an explosive, sulfur-rich eruption occurred at Katmai volcano, along the Novaruptu volcanic complex, in the Alaskan peninsula. R.F. Griggs, funded by the National



NASA

A view from the Space Shuttle of two volcanic eruption plumes from Rabaul volcano, Papua, New Guinea, Sept. 19, 1994.

Geographic Society, documented the frightful events in the Kodiak region, in his 1922 book, *Valley of Ten Thousand Smokes.*

Most people were unaware of the eruption itself, Griggs said, because of the remoteness of the region. However, the abrupt weather changes were immediately known. At Kodiak, 100 miles from the eruption, darkness descended upon the region when ash fell within two hours after the eruption. Ships at Kodiak noted that all streams and wells had become choked with volcanic ash, necessitating the use of onboard ship evaporators to provide drinking water.

On June 7, there were further eruptions; this time sulfurous fumes burned the lungs, and avalanches of ashes on neighboring hills could be heard. During this time, lightning flashed and thunder boomed continuously around the ships. The temperature rose rapidly, breathing became a burning experience, and even the birds fell from the sky.

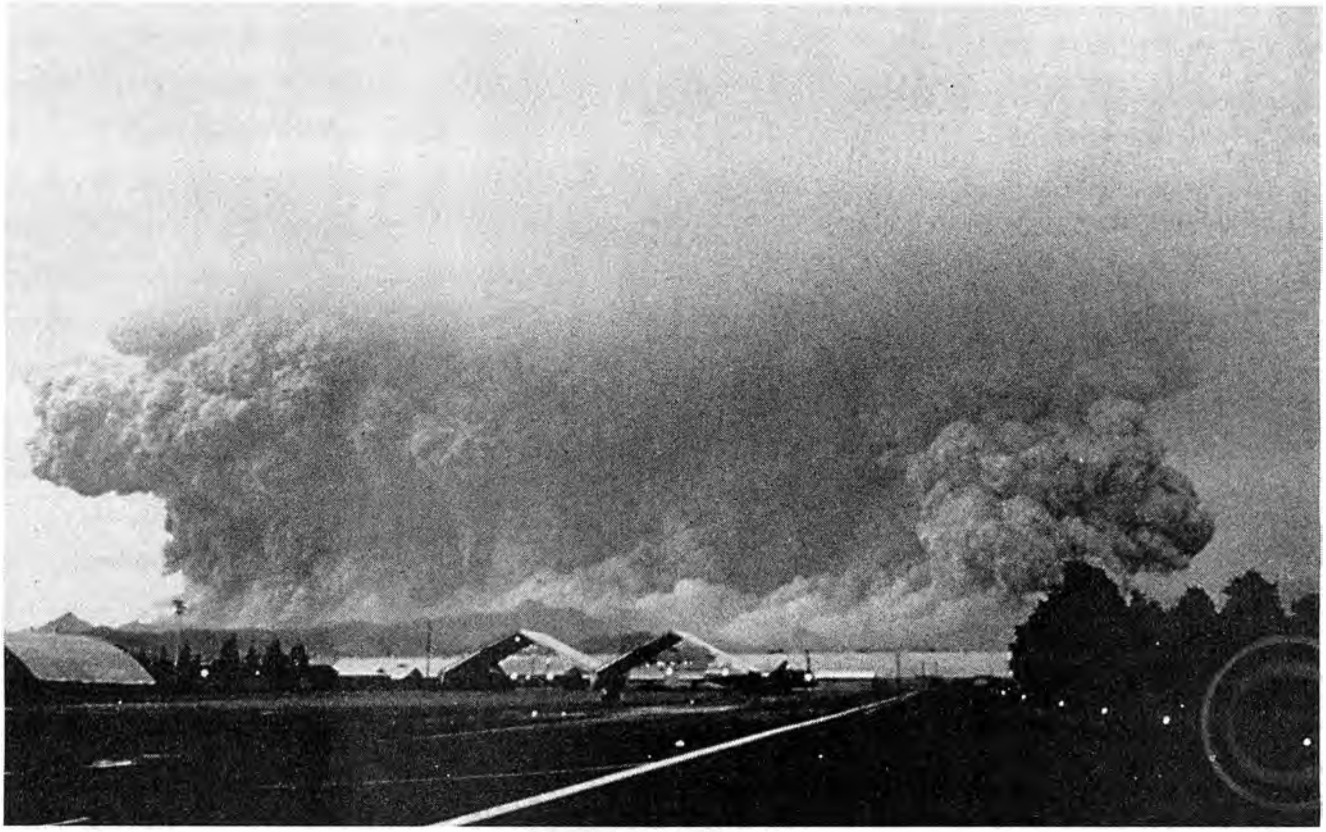
On June 8, when daylight failed to appear, it was decided that the people of Kodiak should be brought together in the storehouse and onboard the ship "Dora" in order to survive. It was impossible even to see from the bridge or observe any landmarks in order to escape to sea. Nevertheless, the ship "Dora" cast off with the people of Kodiak onboard and steered through the narrow channel to Wood Island, rescuing all 103 starving and injured inhabitants. The people of Kodiak and Wood Island returned to their homes on June 10, after two days and three nights of nearly total darkness. The great fear of being buried alive, like the people of Pompeii under the ejecta of Vesuvius's eruption in 79 A.D., had ended.

Earthquake shocks after the eruption were recorded at Georgetown University in Washington, D.C. and explosions were heard as far away as Juneau, Alaska, 750 miles away. Sulfuric acid rains fell at Seward, 250 miles northeast; Cordova, 360 miles northeast; and at Cape Spenser, 700 miles from Katmai, according to Griggs.

The most notable feature was an unusual "haze" spread rapidly from the volcanic cloud to the southeast, almost immediately after the eruption. Griggs documented the movement of the great "haze" as follows:

June 8, 1912: At Madison, Wisconsin, a "curious haze" appeared in the form of streaks in the sky, and rapidly moving wave systems; during the next two days the "haze" became denser, with definite forms difficult to recognize.

June 10, 1912: The "haze" spread to Virginia, and the at-



T.J. Casadevall/U.S. Geological Survey

The eruptions of Mt. Pinatubo, the Philippines, in June 1991, are one of the most important geophysical events of the 20th century.

mosphere was clear until noon on the 10th, when the polarization of sunlight, which was being monitored at that time by H.H. Kimball of the Mt. Weather Observatory, abruptly decreased by 14 percent.

Astronomers Abbot and Fowle were studying solar radiation intensity; Abbot in Bassour, Algeria, and Fowle at Mt. Wilson in California, both in desert regions where the atmosphere was clear. They soon found that their observations were being interfered with by the same unusual "haze."

June 19, 1912: In Algeria, Abbot noted "streaks resembling smoke along the horizon, as if there had been a forest fire [nearby]." Within a day or two, the sky became like "mottled figures," with no clouds present. Solar radiation measurements ceased at that time because of condition of the sky.

June 25, 1912: a cloudy period began, with rain.

June 29, 1912: Abbot noted that when the sky cleared, "we found the whole sky was filled with haze," and this state of affairs continued even more pronounced until the expedition left Algeria, about September 10th."

In both Europe and the United States, the unusual "haze " was noticeable. In 1913, Abbot and Fowle published their results indicating that the "haze" had diminished the effect of the Sun's rays and reflected them back into space. They noted "that the uncommon haziness of the sky during the summer of 1912 produced a very marked decrease in the direct solar radiation in all parts of the spectrum, and reached nearly 20 percent at high Sun for the total heat," as measured simultaneously in California and Algeria. Thus, Abbot concluded that when considering all known factors, "the dust of Katmai diminished the heat available to warm the Earth in the Northern Temperate Zone by about 10 percent during the summer of 1912."

During this same period, Kimball documented worldwide temperature changes and concluded that during June 1912 to October 1913, "the average daily deficiency of temperature for the whole Northern Hemisphere was 0.16°C [0.29°F]." Kimball also noted that "low temperatures persisted generally in low latitudes during the remainder of 1912 and throughout the summer of 1913, with a maximum deficiency for the whole hemisphere of 0.9°C [1.6°F] in September, 1912."

The weather records for this period indicate that the worldwide "haze" after Katmai coincided with a remarkable change in weather, which was particularly extraordinary because it seemed to have occurred simultaneously in virtually all of the independent weather-reporting stations in the United States, as one can see from examining the Department of Agriculture's *Monthly Weather Review* for June 1912.

On June 8, two days after the eruption began, the weather changed from mild and sunny to very cold and in some cases, with heavy precipitation, largely in the form of rain. We found no other case where we can show almost the immediate effect of the eruption. Thus, in early June 1912, directly after the Katmai eruption, we see the development of what can be called "a year without a summer," because this cold weather persisted throughout the following months, through September and in most cases until October.

Pinatubo Volcanic Period: 1991 to Present

We will briefly look at a recent case study: Pinatubo. After having been inactive for 635 years, Mount Pinatubo in the Philippines erupted with great violence to a height of 18 to 25 miles, between 14-16 June 1991, causing darkness to descend on Manila at midafternoon, 55 miles away. The eruptions of Mount Pinatubo are one of the most important geophysical events of the 20th century. Initially, the volcano was estimated to have injected 15 to 30 megatons of sulfur dioxide (SO_2) into the stratosphere. Scientists also noted that in about a month after the eruption, "the sulfur dioxide was converted into sulfuric acid (H_2SO_4), which, in the stratosphere, condenses into small particles called aerosols. The aerosol load after this volcanic eruption was one or two orders of magnitude larger than that produced by biological and anthropogenic sources."

The Global Volcanism Network of the Smithsonian Institution reported that satellite observations, utilizing the Nimbus-7 TOMS instrument, detected a total mass of sulfur in the stratospheric sulfur-rich aerosol cloud which appeared to be "double that of the 1982 injection from [volcanic eruption of] El Chichon." Further research on the extent of the Pinatubo sulfur-rich cloud, indicated that the major stratospheric cloud produced by the mid-June eruption circled the entire world in about three weeks, and formed an almost continuous band around the Earth between 20°N and 20°S. In 1992, the American Geophysical Union Chapman conference on Climate, Volcanism, and Global Change indicated that approximately 20 megatons of sulfur volatiles had been ejected into the stratosphere from Mount Pinatubo. Later estimates were that the 1991 eruption produced the greatest amount of sulfur dioxide during the 1978-1991 period of operation of TOMS, when it measured approximately 20 million tons of SO_2.

Then, on Aug. 12-15, 1991, Mount Hudson volcano erupted in Chile to a height of 10 to 11 miles, with the sulfur dioxide-rich plume being rapidly transported around the Earth. The SO_2 clouds were observed by the TOMS instrument onboard the Nimbus-7 satellite as they circled the south polar region, and contained 1,000 kilotons of SO_2. The researchers indicated that Hudson produced approximately twice the sulfur dioxide outgassed from the Mount St. Helens eruptions in 1980.

The weather appeared near normal for June 1991, but in early July, severe storms battered Romania, Moldavia, and the Ukraine, and parts of Japan, South Korea, and China, causing flooding, while droughts were reported in other areas. Beginning in late-September, six tropical cyclones had slammed Japan, while at the same time the weather in northeastern China changed abruptly from extremely wet, to very dry. In northern and eastern Australia, it was dry, which correlated well with the typical low-index (warm) El Niño-Southern Oscillation precipitation signal in the region. Europe, the Middle East, central and eastern South America were dry for the most part.

Weather abnormalities around the world in 1991 were followed by a brutal winter (December to February 1992) in southern Europe and the Middle East, characterized by heavy snow and very cold weather. In Iran, north-central China, the Pamir Mountains, and southwestern Asia, there were great cold waves in January 1992, and even portions of northern Africa were plagued by severe cold weather.

At the same time, exceptionally mild conditions prevailed across much of western North America, especially southwestern Canada, between January to May 1992, and the Canadian Prairies received less than 75 percent of normal precipitation between January and June 1992. Below normal rainfall established a sixth consecutive year of drought across northern California, southeastern Oregon, and portions of Nevada between October 1991 and March 1992.

In east central South America, heavy rainfall was noted from January to July, with exceptional floods reported. In southern Africa, a severe drought profoundly affected agricultural production and food shortages between February and May, and was noted as the region's worst drought of the century. Severe dryness also plagued the region of Sri Lanka and southern India between January and March.

During the summer and early fall of 1992, five of the most powerful wind storms of the century went into the record books: Between Aug. 23 and 29, Hurricane Andrew became the most destructive, costly storm ever to strike the United States, with $20 billion damage reported. Numerous challenges confronted eastern North Pacific mariners during the 1992 hurricane season. A record 27 tropical cyclones menaced the area, breaking the previous record of 26 storms set in 1982, after the eruption of El Chichon.

Then in September, Hurricane Iniki, with sustained winds of 145 mph, caused more than $1.6 billion damage to the Island of Kauai in the Hawaiian Islands. This was the strongest hurricane to hit these islands in the 20th century, and the costliest in Hawaiian history. From Nov. 8 to 22, Typhoon Forrest slammed into Bangladesh and the Bay of Bengal, causing deaths in the tens of thousands, with record wind speeds of 230 mph.

The dominant climate event of 1993 was the great flood of record in the central United States, during the summer. The combination of the persistent trough and a strong jet stream propagated a large number of cyclonic storms, fueled by an ample supply of moisture. These downpours fell on areas already saturated by well above normal precipitation, July 1992 to March 1993, resulting in the widespread catastrophic summer floods.

Nearly 16,000,000 square miles of land was covered by water at some point during the flooding. New record high river levels were reported across much of the Mississippi-Missouri River complex north of the the Ohio River confluence during summer, with the river at St. Louis remaining above flood stage for 80 days. More than 75 percent of the levees across the region were breached or overtopped. By the time most rivers finally receded in early September, damage estimates topped $11 billion.

While flooding ravaged the central states, the same persistent circulation pattern steered storm systems away from the southern and eastern sections of the nation. As a result, abnormally hot and dry weather covered much of the Southeast and Atlantic Seaboard. During early July, an intense heat wave aggravated the unusually dry conditions across this region.

The seasons following the eruption of Mount Pinatubo in 1991, show the same pattern as recorded in other volcanic periods: record wind storms, hurricanes, cyclones, record cold episodes, along with droughts of record proportions in some areas, with great floods in other places. It is of interest to note that these highly abnormal weather conditions clearly exist with, or without, a warm-water El Niño episode.

The Unanswered Questions

Historical documents have made it possible for us to analyze vast amounts of information concerning changing weather patterns worldwide, and specifically for southern California, during the past two centuries. The historical eruptions and the recent volcanic eruptions of Agung (1963 in Bali), Nyamuragira (1981 in Africa), El Chichon (1982 in Mexico), Mount Pinatubo (1991 in the Philippines), Mount Hudson (1991 in Chile), and Klyuchevskoi (1994 on the Kamchatka Peninsula in Russia), have a common link: They all preceded severe storms that have been particularly devastating. We note that record storm years have occurred following significant volcanic eruptions, whether or not a warm-water El Niño-Southern Oscillation episode was occurring.

Atmospheric, chemical, and Earth scientists have become concerned about these sulfur aerosols, after seeing the effects of volcanic aerosols that were introduced into the troposphere and stratosphere after the 1963 Agung eruption in Bali and the subsequent eruption of El Chichon in April 1982, along with other volcanoes erupting along the "Ring of Fire," such as Galungung in Indonesia (1982), Manam in New Guinea (1982), Raung in Java (1982), Soputan in Indonesia (1982), and Nyamuragira, which was continuously erupting in Africa (1982). In early 1983, three more volcanoes erupted: Sakura-Jima in Japan, Langili in New Britain, and Bezymjanny in the Kamchatka Peninsula.

Another significant eruption was reported at Redoubt Volcano in Alaska in 1989. Then in June 1991, the largest eruption of the 20th century occurred at Mount Pinatubo in the Philippines, and, shortly thereafter, in August 1991, Mount Hudson in Chile erupted. A brief hiatus lasted until Bezymjanny Volcano once again exploded in October 1993, and Klyuchevskoi in October 1994 on the Kamchatka Peninsula.

It is clear from the historical data that the cumulative effect of injection of volcanic ash and aerosols from all of these eruptions must be considered when examining regional and global weather effects recorded in the post-El Chichon period. It is also important to note that one of the strongest El Niño-Southern Oscillation events of the 20th century occurred during the same period as the volcanic eruptions of 1982-1983.

Between 1947 and 1977, we enjoyed one of the most benign, quiescent, and storm-free periods, going back to the year 1550. It now appears that the Earth has entered a period of increased volcanic activity, much greater than all previous decades of the present century combined. What is required is an interdisciplinary effort, not just to monitor effects, but to use the historical knowledge, some of which is reported here, to try to understand the relationship of volcanic activity, weather, and climate.

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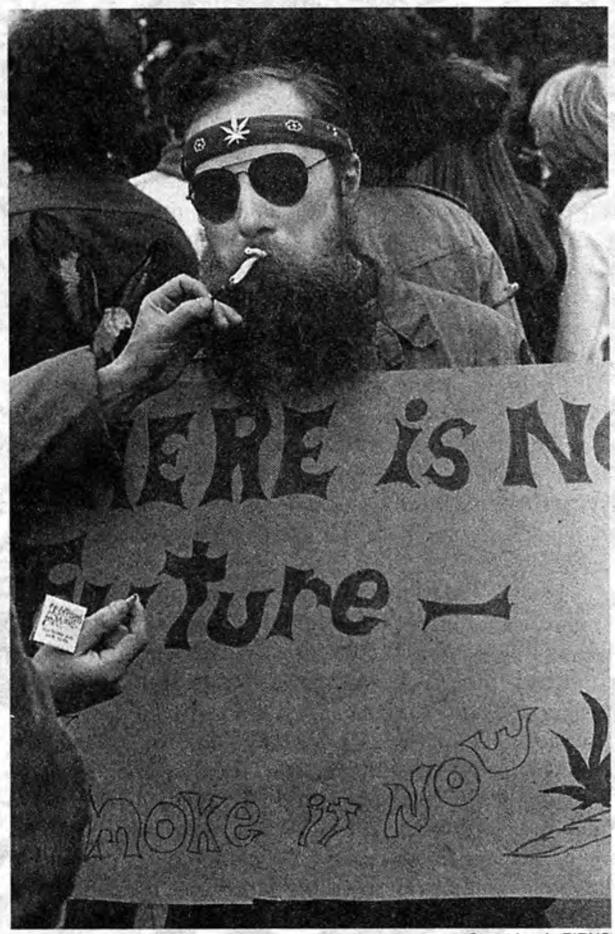
The Medical Effects Of Marijuana On the Brain

New research on marijuana confirms that it damages cognitive functioning. Pot legalization would spread this disability.

by Karen Steinherz
and Thomas Vissing



Stuart Lewis/EIRNS

USDA Drug Enforcement Division

How many victims of the counterculture have suffered cognitive damage from marijuana smoking?

Marijuana is the most widely used illicit drug in the United States and Europe, and tends to be the first illegal drug that teens use. In the United States, it is estimated, conservatively, that more than 5.5 million adults smoke the drug weekly.

Although *Cannabis sativa,* or marijuana, has been in use for at least 4,000 years, it was not until 1964, that Israeli biochemists R. Mechoulam and Y. Gaoni isolated the principal psychoactive ingredient of the marijuana plant: delta-9-tetrahydrocannabinol. Delta-9-THC is the substance in the plant that produces the "high," the feeling of intoxication, that users crave.[1] The marijuana plant contains more than 400 chemical compounds, of which 60 are cannabinoids—psychoactive compounds that can be extracted from the cannabis plant, or produced within the body after ingestion and metabolism of cannabis.

Here, we analyze the ramifications of some of the most important scientific discoveries about marijuana and its negative impact on the brain. Marijuana can also cause damage to the lungs and the reproductive system, but that will not be reviewed here. Naturally, the brain is part of, and absolutely dependent on, the functioning of the rest of the organs of the body, for example, for its glucose and oxygen supply. But the brain is in charge of the body; it is the physical substratum of the intelligence, memory, will, and emotion. The human species alone can bring to bear its brain—its intelligence—to change the world around it for better or worse.

Delta-9-THC is found in the resin located mostly in the flowering tops of the plant, with a smaller amount in the leaves, and the least amount in the fibrous stalks. As a result, the psychoactive potency of a cannabis preparation varies enormously, depending on which part of the plant was used to make it. The most powerful form is from the pure resin removed from the leaves and stems; this is known as hashish. Its concentration of delta-9-THC is about 8 to 14 percent. Next in potency is ganja, which is very commonly smoked in the United States. (Unless otherwise stated, we are referring here to the smoked cannabis form of administration, except, of course, in animal experiments.) Ganja is made up of dried plant material taken only from the tops of unpollinated female plants. Known as sinsemilla, this version of marijuana has a THC content of from 4 to 8 percent.[2]

In Holland there are varieties of cannabis for sale with delta-9-THC levels averaging 20 percent, which has led to concern about the high potencies and the resulting psychoactivity. Whether or not the potency levels of other types of cannabis are leveling off in the late 1990s, or are climbing to the levels of Dutch potencies, or beyond, is still an area of much controversy, and the scientific community as well as police forces in the United States and Europe are tracking the issue.

Marijuana Targets the Brain

The principal target of delta-9-THC, as with all drugs of abuse, is the brain, and therefore, researchers concentrated their efforts into investigating the effects of this plant constituent on the body's most important organ.

Cannabis, like nicotine, is normally inhaled, and therefore has rapid access to the blood system. The drug and its metabolites are lipophilic (fat soluble), and thus are easily able to pass through the blood-brain barrier, which controls the passage of many substances into the brain. Even antibiotics, or drugs for cancer treatment, do not cross this barrier; yet, cannabis is able to penetrate the two layers of cells that form the blood-brain barrier. After metabolism in the lungs and liver, into its metabolites, THC moves rapidly to lipid-rich tissues in the body, including the brain.[3]

The user's most common reported feelings under the influence of cannabis are a release from stress, a loosening of associations, and euphoria.[4] It can be a euphoriant, or an excitant, and it can change. As investigators have found, marijuana is dose-dependent, with intoxication most intense for the first two to three hours. The user's past psychological history, his experience with marijuana, and the social setting all play a role in marijuana's influence, in correlation with the drug's chemical complexity and myriad personality effects.

Because THC and its metabolites are fat soluble, they may remain in the fatty tissues of the body for a long time. Later they are released into the bloodstream. There is substantial human variability in the metabolism of cannabis, but it is now proven that individuals who use cannabis daily are more at risk than infrequent users, because of the slow release of THC. The time necessary to clear half the administered dose of THC differs for experienced and inexperienced users, with experienced users accumulating more THC in their systems.[5]

The plant constituent delta-9-THC has been found to produce many characteristic cognitive deficits in both human and animal subjects. It impairs the brain's functioning, particularly with regard to chronic use. Numerous investigations have found that the most pronounced impairments are reduced short-term memory, locomotion disorders, altered time sense, paranoia, fragmentation of thought, and lethargy.[6]

Until 1988, when specific cannabinoid receptors were found in the brain, the mode of cannabinoid action in the human body was not at all clear. There was little biochemical or neurological proof to link these type of behavioral disorders with the actions of specific mechanisms. Pharmaceuticals that mimic THC's effects, called analogues, were not then available for studying the the pharmacological kinetics of marijuana. Because of this lack of conclusive research findings in precisely those areas that establish addiction—that is, the ability of a drug to create dependence and cognitive disorders—marijuana became the subject of much public controversy. The media and the pot legalization lobby labelled marijuana a "soft" drug. By distinguishing it from the opiates—cocaine, alcohol, or the methamphetamines, which are categorized as "hard," or addictive—the legalization lobby minimized the risks of cannabis use.

New Discoveries in an Old Field

Starting in 1988, researchers made new discoveries on the mode of action of marijuana on the biochemical and molecular level. With the help of these findings, marijuana research is in a new, exploratory phase, and scientists are tracking how cannabis consumption specifically alters the physical functioning of the hippocampus, cortex, pituitary gland, and basal ganglia. We caution, however, that most of this research, although extremely useful, assumes a mechanistic view of the brain's functioning.

Marijuana research goes back to the 19th century. The prominent French psychiatrist, Jacques-Joseph Moreau, (1804-1884), is known as the father of modern psychopharmacology. He was the first medical man to do systematic work with drugs active in the central nervous system, and to catalogue, analyze, and record his observations. Moreau wrote the book *Hashish and Mental Alienation* in 1845, and his work is as applicable today as it was then.

Moreau identified the fact that marijuana's effects on the brain were both many and subtle, and therefore not always visible to the naked eye. After observing the acute behavioral changes hashish caused in some of his mental patients at the famous Charenton mental hospital in France, he wrote:

> Yes, unquestionably there are modifications (I do not dare use the word lesion) in the organ that is in charge of mental functions, but these modifications are not those one would generally expect. They will always escape the investigations of the researchers seeking alleged or imagined structural changes. One must not look for particular abnormal changes in either the *gross anatomical or defined histological structure of the brain; but one must*

look for an alteration of its sensibility. That is to say for an irregular, enhanced, diminished, or distorted activity of the specific mechanism upon which depends the performance of mental functions [emphasis added].[7]

The "distorted" activity which Moreau described, are actions that originate from the effects of marijuana on the central nervous system. The human central nervous system contains three major structural components:

• The midbrain and brain stem control basic autonomic responses and the elementary movements associated with locomotion, feeding, and copulation.

• The cortex—the mass of "gray matter" at the top of the mammalian brain, which is substantially larger among primates than other mammals—specializes in complex information processing. In humans, the cortex is the thin uppermost layer of the cerebrum, which consists of two hemispheres. The cortex is associated with verbal language, memory, and the abilities necessary for reading.

• The limbic system, or the third system, consists of structures between the midbrain and cortex, like the amygdala and the hippocampus. In mammals, it is hypothesized that this system is associated with the emergence of emotion and the development of more complex learning and social behavior.

The human brain weighs three to four pounds and contains about 100 billion neurons. These polarized nerve cells receive signals on highly branched extensions of their bodies, called dendrites, and send the information along unbranched extensions, called axons.

There are a multitude of complex physical interactions in the brain. In the conventional view, which is, as noted, mechanistic, communication among neurons is mediated by chemical transmitters that are released at specialized contacts called synapses. The chemical transmitters are called neurotransmitters, and they process the chemical messages that enable brain cells to communicate; the receptors might be thought of as tiny doors on cell surfaces that allow messengers in.

Recent Research Advances

In 1988, William Devane, et al. found a specific cannabinoid receptor in a rat brain[8] and subsequently, the distribution of this receptor in the human brain was mapped.[9] Today, it is generally accepted that cannabis acts on specific cannabinoid receptors in the brain. (Interestingly, the opioids also act through specific receptors.) The cannabis receptors sit on the cell membranes of the nerve cells. In humans, the highest densities of receptors were found in the basal ganglia and the molecular layer of the cerebellum, which is consistent with cannabinoids' interference with movement. Dense binding was also found in parts of the hippocampus, and the dentate gyrus and layers I and VI of the cortex. The latter is consistent with the findings of investigators, over the years, that the pri-

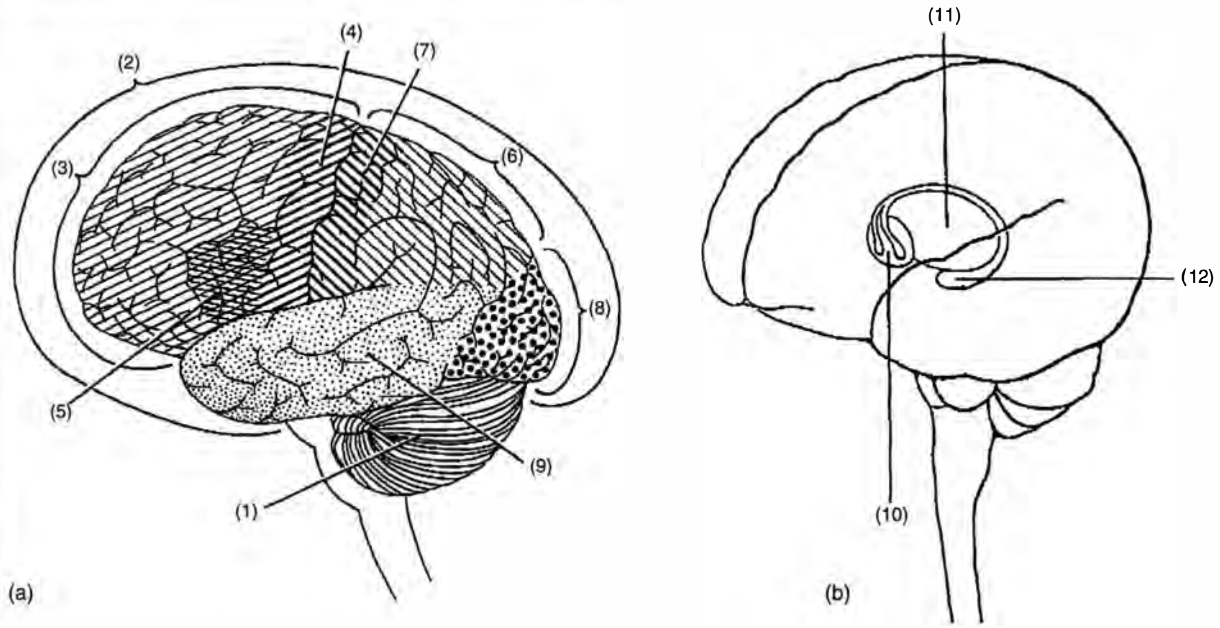


Figure 1
THE ARCHITECTURE OF THE BRAIN
Sketched in (a) are the positions of different parts of the brain: (1) The cerebellum; (2) the cerebrum; (3) the two frontal lobes; (4) a motor area, which helps control voluntary movement; (5) Broca's area, which is related to speech; (6) the parietal lobes; and (7) the primary sensory areas; (8) the occipital lobes; and (9) the temporal lobes. Coating the surface of the cerebrum and the cerebellum is a thin layer of tissue called the cortex, which is commonly known as "gray matter."

The inner brain is sketched in (b): (10) the hypothalamus; (11) the thalamus; and (12) the hippocampus. Cognition is altered by marijuana's impact on the hippocampus.

Source: National Institute of Neurological Disorders and Stroke

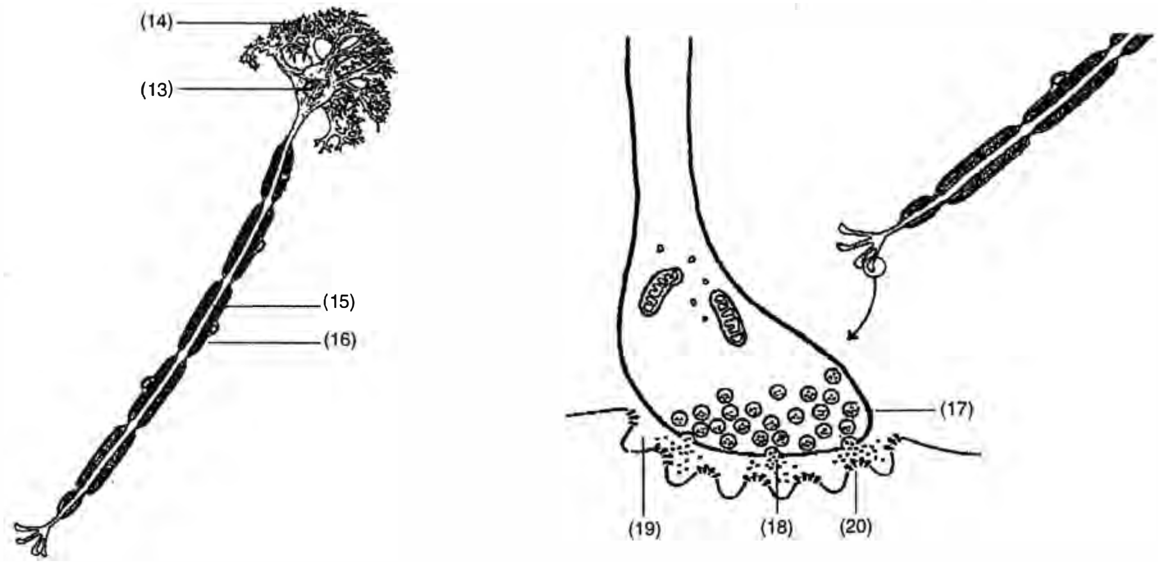


Figure 2
NEURONS AND THEIR COMMUNICATION SYSTEMS
Neurons (a) have three parts: (13) the cell body, which contains the nucleus, where the molecules that the neuron needs to survive and function are manufactured; (14) dendrites, which extend out from the cell body and exchange messages with other nerve cells; (15) axons, through which signals pass from the dendrites through the cell body; and (16) an insulating sheath for the axon.

When a signal reaches the end of the axon, it stimulates tiny sacs (17), which release chemicals known as neurotransmitters (18), into the synapse (19). These neurotransmitters cross the synapse and attach to receptors (20) on a neighboring cell.

Source: National Institute of Neurological Disorders and Stroke

mary effects of marijuana were on the cognitive faculties.

In 1990, Lisa Matsuda provided conclusive evidence documenting the damage of marijuana on the cognitive faculties, after cloning a gene for the cannabinoid receptor in the rat brain which, in collaboration with M. Herkenham, was found to be 97 percent identical with the human receptor.[10] Interestingly enough, the cannabis receptor was also located in the nervous system of lower vertebrates like chickens, and even trout, suggesting that the gene must have been present early in evolution. The conservation of this gene implies that the receptor serves an important biological function in the body. Later, another receptor was found, in the spleen, and still a third was found in the uterus.[11]

Naturally, the rodent brain, or that of any animal, for that matter, cannot be compared to the human brain. But there are many effects, such as the impact of cannabis on movement, that are easier to evaluate with animals, because it is possible to maintain tight control over laboratory conditions, doses, and animal history. Investigators then project these results onto humans, making enormous qualitative allowances for the species differentiation of the brain.

In 1992, another crucial discovery was made. William Devane and Raphael Mechoulam, working at Hebrew University in Israel, pinpointed a naturally occurring brain molecule, anandamide, that binds to the cannabis receptor and creates a "high" similar to that of marijuana. Anandamide is a compound derived from fatty-acid, which possesses pharmacological properties similar to those of delta-9-THC. This would indicate that smoked marijuana operates through a specific biochemical system that already exists in the body. If receptors for exogenously supplied substances exist, then there must also exist corresponding chemically related substances, which occur naturally in the body, and are very similar.[12] The anandamide is found particularly in the hippocampus, the thalamus, and in the cortex structures of the brain.

Although these two discoveries contribute to our knowledge of how cannabinoid action works in the body, they also raise some puzzling new questions. For example, in laboratory rats, anandamide was shown *not* to have the same strength of effect on spatial memory in rats as did delta-9-THC. Does this mean that the naturally produced cannabis, the anandamide, is different from smoked cannabis? And if so, why? What, then, is the purpose of anandamide? Under what conditions is anandamide released? Scientists are now trying to figure out the actual function of this system.[13] Surely it does not exist in the body so that humans could smoke marijuana.

Short-term Memory Damage

In a useful review of the scientific literature, conducted in 1983 by Miller and Branconnier, they found that the most consistently reported cognitive deficits from chronic marijuana smoking were memory deficits.[14] Scientists today consistently voice concern over the effects of marijuana smoking on short-term memory. Physically, it is the hippocampus in the brain where researchers locate the series of actions that converts information into short-term memory, and perhaps, also, long-term episodic memory and "gates" information for memory consolidation, as well as coding spatial and temporal relations among stimuli. Scientists think that they have a long way to go before they understand the hippocampus fully. Since the discovery of the cannabinoid receptor family, researchers know that high numbers of cannabinoid receptors exist in this structure, as well as the anandamide.

How human memory literally goes up in marijuana smoke, by its medium- and longer-term effects on the hippocampus, was graphically described by Professor Samuel Deadwyler from the Bowman Gray School of Medicine in North Carolina, in a speech at the 1995 National Conference on Marijuana Use, sponsored by the National Institute of Drug Abuse:

> It is this area, when damaged, that renders patients literally incapable of remembering new information for more than a few minutes and is *undoubtedly critically involved in the well-known memory deficits in Alzheimer's disease.* When these hippocampal marijuana receptors are stimulated, they have the effect of rendering the hippocampus inactive.
>
> Long term exposure to marijuana has dual consequences for the memory. First, repeated exposure to marijuana in animals makes them more and more tolerant of this memory disruptive effect. However, this also means that continued use of the drug requires higher and higher doses before the euphoric or high state is achieved. Hence, even though memory is not impaired at the same dose as before, it will be impaired just as much because the individual will take more drugs to obtain the original euphoric state. What this means is that chronic use will eventually produce permanent effect on memory since the hippocampus will adjust its memory storage mechanisms to handle the lower capacity or volume of information flow produced by the drug. Thus, even when the drug is not present, *the hippocampus will be altered and reduced in capacity to perform at optimum level.* This may be the basis for the well-known memory deficits that are present in chronic marijuana users [emphasis added].[15]

Deadwyler and his associates have been preoccupied, for at least 10 years, with obtaining more detailed information on how this structure actually works. Deadwyler found that delta-9-THC selectively suppresses hippocampal electrical cellular activity in rats. He also located the fact that the granule cells provide a critical link between the entorhinal cortex and the hippocampus. Another scientist, K.A. Campbell, found in 1986 that the dentate gyrus, an area of the hippocampus, has its sensory decoding disrupted by THC.[15]

Neural pathways are conventionally thought of as electrical circuits, either parallel or serial. Understanding the brain's organization of the cannabinoid circuitry and its relation to other brain circuitry, not only could help to elucidate the function of the body's cannabinoid system, but also could give us more specific data on the workings of the hippocampus, and memory itself.

Such research is ongoing. Dr. Billy Martin's laboratory in Virginia, for example, has been researching the effects of THC for more than 20 years. Recently, Martin and Lichtman have presented data showing, for example, that cholinergic and cannabinoid receptors are *not* in series in disrupting memory in the hippocampus.[17] Acetylcholine is a neurotransmitter released by the cholinergic system, which seems to direct attention and maintain attention. Higher intellectual functions, such as memory and learning, require controlled attention. The fact that both cholinergic and cannabinoid receptors exist in the hippocampus, and in other brain areas associated with memory, would suggest the possibility that these two neural pathways work together, but how this happens is still not understood.

Brain scientists freely admit there is still much uncertainty about the operations of the hippocampus; for example, consciousness is possible even when the hippocampus is removed. But, as one researcher stresses, one crucial thing is certain: Long-term and short-term memory survive such a lesion "but *transfer from the former to the latter becomes impossible* [emphasis added]."[18] No matter how one looks at the function of memory, it is obvious that man needs his hippocampus. Children and young adults, in particular, depend on their short-term memory, since they are learning and receiving new input constantly.

In addition, the hippocampus is dependent on information processing and input from other brain areas that are affected by cannabis smoking. For example, there are many cannabinoid receptors on the cerebellum. The cerebellum processes information which is largely related to motor function. The frontal lobes, which process temporal relations, also have cannabinoid receptors. Given the number of regions of the brain that are affected, this means that, ultimately, the entire brain, and the entire body, will be affected.

The cognitive drawbacks of cannabis-caused impairment are not inconsequential. They affect driving a car, operating a plane, or employing a complicated piece of machinery. In such skilled activities, one's undivided attention, recall, quick visual-spatial mapping, and split-second timing, are required at every second.[19] Or to take a simpler example, what about the young adult who is attempting to learn how to play the trumpet. How can the student who has smoked too much marijuana simultaneously have command over the complex processes required to perform a piece of music—memory, coordination of hands and mouth, emotion, and interpretation?

The Neuroendocrine System and Cannabis

Another important aspect of brain and long-term effects of chronic cannabis use is its effect on the hippocampus and its hormone system. Researchers J.C. Eldridge and P.W. Landfield are studying the relationship between the glucocorticoid receptor system in the hippocampus, and chronic cannabis use. Glucocorticoid, is a steroid that is secreted in times of stress. They write:

> Chronic THC administration induced aging-like degenerative changes in the rat brain that resembled . . . the effects of stress exposure and elevated corticosterone secretion.[20]

Argonne National Laboratory

A research team headed by Dr. Eliezer Huberman, at Argonne National Laboratory, has shown that active ingredients in marijuana, THC and related cannabinoids, keep blood cells from maturing, thereby reducing the body's ability to fight disease. Here, Huberman (left) examines a protein map that reveals the individual proteins in blood.

Eldridge and Landfeld's work was conducted before the discovery of anandamide, so that they did not have the benefit of knowledge of the cannabis "lock." Nevertheless, their work on the interactions of marijuana with the hormone system of the body is very useful, for hormones play a central role in regulating the body's reaction to stress, and because marijuana is used ostensibly to relieve stressful situations.

The importance of hormones can be seen in looking at the effects of cannabinoids on pituitary hormone secretion. The pituitary gland secretes eight different hormones that play crucial roles in regulating metabolic and reproductive functions throughout the body. The adrenocorticotropin hormone (ACTH) is released in response to stress. The thyroid stimulating hormone (TSH), and the growth hormone (GH), are important in the maintenance of metabolism. Studies indicate that chronic and acute use of marijuana may have an effect on the reproductive system and the individual's ability to respond to different metabolic changes and stress.[21] Some researchers also believe that too little stress is unhealthful for the brain, for then the brain is not in gear.

Biophysical Clues

Today, most scientists study how cannabis affects cells by chemical and electrical methods of examining neurons in the brain. In this method of investigation, scientists identify how membranes and proteins interact. Proteins are a large family of biological molecules, which are made by stringing amino acids together to form long chains. There are many kinds of proteins; they are the "machine tools" of the cell. Enzymes, for example, are made of protein, as are the ion channels that move ions across cell membranes. It is the movement of ions across cell membranes which is conventionally thought to be the main method for electrical signalling in the brain.

There have been many experiments on understanding the electrochemistry of the 9-delta-THC molecule, and the pharmacological kinetics of the THC-cell receptor bindings. Also, much has been done on non-receptor membrane interactions with cannabis.[22] Naturally, after the post-1988 discoveries of the cannabinoid receptors, the cannabis receptor and linked anandamide research became the most logical, and fruitful, method of investigation.

However, another avenue for examining how the psychoactive substances of cannabis, the cannabinoids, work is to perform biophysical experiments and measurements, looking at the physical interactions between the drug and the part of a living cell it targets, on a microphysical scale. This method has promising results for investigations of the medium- and long-term effects of cannabis on the brain and nervous system. The biophysical method of investigation asks different questions about cells than does the biochemical avenue. For example, are there changes in the physical state of a membrane that correlate with how THC molecules behave?

A few words about the importance of the membrane. Each cell is surrounded by a double layer of lipid, called the lipid bilayer. Lipid is a name for certain organic molecules that have one water-attracting end, and one fat-attracting end. A typical cell membrane is about 5 nanometers thick, compared to a cell dimension of 1 to several micrometers in cross-section. (If the inside of a cell were scaled up to be as large as a big living room, the cell membrane would still be only a couple of centimeters in thickness.)[23]

Traditionally, one can think of a cell as being like a well-organized city, which contains water and different organelles, including the DNA, as the chemistry takes its course. The cell itself is full of membranes, because many parts of the cell have a surrounding frame, or bilayer. The nucleus, and the golgi apparatus, for example, are surrounded by a membrane. Thus, most biological processes have to interact with membranes. Phosphocholines (DPPC) are the main constituents of biological membranes; other constituents include the sterols and cholesterol.

Alexandros Makriyannis and colleagues, working at the University of Connecticut at Storrs, have been doing biophysical work with cannabis, for some time, in collaboration with other institutions. Synthetic membranes can be made very simply by dispensing lipid molecules in aqueous solutions. Using such model membranes is extremely useful, because it is possible to ask simple questions and have control over the physical properties. The Makriyannis group added THC molecules in varying concentrations to the model membranes, and then applied different spectroscopic techniques in order to measure the change induced by THC.

Another technique this group used is called differential scanning calorimetry, which makes use of the coupling between the temperature and the phase transition of a lipid bilayer. By using different analogs of the principal active ingredient, the delta-9-THC, in mixing with the model membrane DPPC, the Makriyannis group found that the gel states disappeared; they also found that the gel-to-fluid change was different when active THC-analogs were increased.[24]

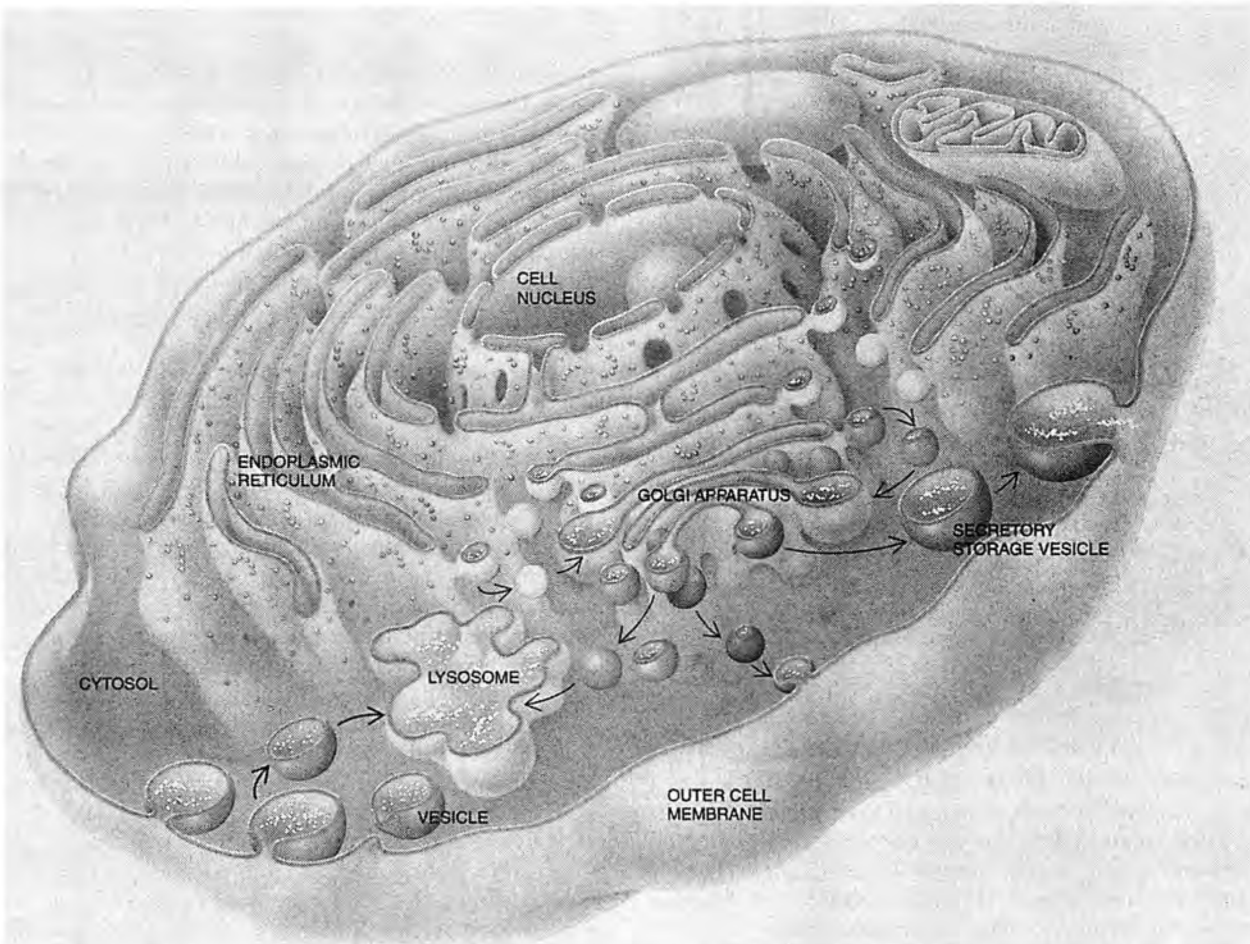


Figure 3
TRANSPORT VESICLES IN THE CELL

The cell is like a well-organized city. This artist's illustration shows the various transport vesicles in a cell. Some convey proteins made in the endoplasmic reticulum to the Golgi apparatus, which modifies the proteins. Others transport proteins and enzymes in and out of the cells, or store them. Scientists have found that the THC cannabinoid causes subtle changes in cell processes.

Source: Tomo Narashima/*Scientific American*

A lipid bilayer has the ability to change between different physical states, which is important for biological processes in the cell. The fact that THC causes these tiny changes is significant, because of the physical dependence of cellular membrane structure on biological activity. It also points to the potential influence of THC as a membrane "perturber," with implications, ultimately, for the brain and the entire body.

Although the cannabinoid receptors and anandamide, have been identified—that is, there is a specific biochemical system for cannabis's psychoactive effects to be pharmacologically set into motion—this biophysical approach should not be abandoned. According to Mavromoustakos and Makriyannis, et al., it appears that not all the impacts on the body from cannabis smoking are cannabinoid-receptor related. As proof of this, for example, the researchers cite the impact of cannabinoids on neurotransmitter uptake systems and on blood platelets.[25] And researchers have admitted that chronic cannabis users may have symptoms even in the long-term and non-intoxicated state, long after cannabis is no longer detectable in the blood or fat.[26] Perhaps in the future, membrane research could explain some of these phenomena.

The overriding consideration here is that the entire brain and the entire body depend on each other and operate together. We cannot underestimate the impact, sometime in the future, of subtle effects such as those Moreau noted in the 19th century, which have their origin in tiny microphysical changes in the brain's substratum. Moreau once referred to this phenomenon as a "molecular disintegration" of personality, which is what we will next examine.

Marijuana As a Personality 'Agent Provocateur'

So far we looked at some individual structures of the brain and then at the microphysical level. Putting the head back on top of the person's body, now we might ask, how does the mind of an individual under cannabis's influence actually work? And what are the visible signs of this in the person's behavior?

Jacques-Joseph Moreau (1804-1884), a prominent French psychiatrist, was the first medical man to do systematic work with drugs active in the central nervous system, and to catalogue, analyze, and record his observations. His 1845 book, Hashish and Mental Alienation, *is still applicable today. Moreau termed marijuana a personality "agent provocateur."*

The psychiatrist Moreau tested cannabis not only on his patients, but also on himself and his colleagues in the literary circle, Le Club des Hachichins. In fact, Moreau administered doses far exceeding that which any scientist today would be allowed to use. Without any government restrictions, Moreau dared to use up to 16 grams! When one reads his results, therefore, one has to be careful about the interrelationship between the high dose of which he is speaking, and the pre-existing mental state of his subject. Nevertheless Moreau's observations are still relevant.

As did later researchers, Moreau discovered in his experiments during the 1800s, that marijuana's effects are dose dependent. If the dose was high enough and the use chronic, Moreau observed that his subjects often became insane. With the administration of lower doses, Moreau identified long-term personality changes that were more subtle, including shortened attention span, distractability, and a progressive loss of mental powers. Moreau did not view the progressive destruction of the individual's mental powers, under the chronic use of marijuana, as simply a linear addition of one more cognitive deficit in a human performance test. He stated that any individual under the chronic use of marijuana was "mentally disturbed." Moreau wrote, based on his observations and scientific knowledge, that by destroying the unity of thought in the individual, that individual was mentally ill, even if he did not look like, or act like, a psychotic. Moreau did not think one could automatically see this devolution in the initial stages with the naked eye:

> Such are all, or almost all, the physical disorders caused by hashish from the weakest to the most intense. One sees that they all relate to the nervous system. As we have already said, they develop much more slowly than the mental disturbance, *and the mind can be profoundly changed without affecting the body. It seems that the causal factor* [that is, the drug] *acts directly on the faculties of the mind without the mediation of the organs, as in the case of mental illness* [emphasis added].[27]

Moreau identified how the mind is destroyed from marijuana smoking, notably through distractability:

> One of the first measurable effects of hashish is the gradual weakening of the power to direct thoughts at will. We feel slowly overwhelmed by strange ideas unrelated to the subject on which we are trying to focus our attention. These ideas, which we have not willfully summoned in our mind, appear at random and become more and more numerous, lively, and keen. Soon they command more attention and generate bizarre associations and fantastic creations. If by an effort of will we resume the sequence of our ideas, the ones we have rejected still echo in our mind, but as if from a faraway distance muffled like dreams of a restless night. . . . [T]hese ideas, or rather this series of ideas, are actually dreams, "true dreams" in the strictest sense. One cannot distinguish them from those created by natural sleep. . . . You forget those things which at present most excite your interest and stir your passions, which absorb all your attention, to dream only those which were in the past.

A little further on, Moreau summarized this process, stating, "The action of hashish weakens the will—the mental power that rules ideas and associates and connects them together."[28]

Moreau's observations find frequent corroboration today. A comprehensive paper, "Effects of Smoked Marijuana on Human Performance: A Critical Review," by investigators L.D. Chaitt and J. Pierri in 1992, reviewed and analyzed many years of marijuana investigations on human beings. In addition to the well-known short-term memory deficits from cannabis usage, these researchers found that another reported result of the human studies were frequent memory intrusions.[29] (Memory intrusions are stimuli listed by the test subjects that are not actually present.) Also, they found reports of significant effects on time estimation. One of the researchers they cite, Nadaia Solowij, a cognitive scientist in Australia, recorded such memory intrusions, among other observations. She postulated that chronic use of cannabis might account for this, by creating long-term changes at the cannabinoid receptor.[30]

If Moreau were alive today he would probably say that the individuals in these studies have an "agent provocateur," a term he coined for the effects of marijuana upon the nervous system. Slowly, subtly, the will of the person is being undermined.

Psychological Predisposition?

Professor Ann Pollinger Hass, who works at the City University of New York, studied 300 marijuana users over six years, and found that the motivation for taking marijuana was that the drug helped to suppress intense anger. As she wrote,

> Chronic use allowed these youngsters to withdraw from conflicts about achievement and competition. It was used to encourage grandiose expectations, feelings of invulnerability, and a sense that a magical transformation of their life was possible.[31]

The question arises, is the marijuana reinforcing a *pre-existing* lack of self-esteem, or infantilism? Among such researchers, there is a heated discussion about whether cannabis use induces psychosis, or whether the person who uses the drug has a psychological predisposition that drew them to drug use in the first place?[32] In any case, as Moreau pointed out, the drug itself can activate mental problems. However, this question of what came first, psychological pressure or the cannabis, is used by the pot legalization lobby to deny that marijuana is the cause of teen problems.

We live in a society where the popular culture advertises that marijuana is relatively harmless. Because of the breakup of the family, the destruction of traditional institutions and values, and the ordinary pressures of adolescence, teenagers have their attention easily drawn to drugs as an easy and pleasurable way out of conflict, or any difficulty. Marijuana is also America's number one cash crop, so it is certainly easy enough to find.[33] Given this situation, it is all the more reason to keep marijuana illegal.

What about the children of marijuana users? Professor Peter Fried has found in preliminary work that children between 9 and a half years old to 12 years of age suffered from a deficit in what researchers term "executive function," a type of cognitive intelligence involving planning for both the present and the future. In his tightly controlled study, children of 120 marijuana-smoking mothers were evaluated on a regular basis from birth. These children were found to have problems in focussing their attention, and were highly distractable. Fried summarized the situation of the mothers as follows:

> [T]here is a lot of evidence to suggest that marijuana has a tremendous impact on the prefrontal lobe and functioning associated with that part of the brain in marijuana users. In addition, the prefrontal area in animals is one of the areas of the brain where there is a high concentration of cannabinoid receptors.[34]

Researchers are currently working on questions such as, how cannabis can be transferred through the mothers—is it through the milk during lactation, or through the placental blood during gestation? How is the nervous system of the developing child altered when the mother smokes? Is the children's diminished learning ability in adulthood based on prenatal and perinatal exposure to delta-9-THC? Although this research is far from complete, it certainly poses interesting challenges for marijuana research—as well as life and death questions about drug abuse for developmental embryologists.

The Origins of the Marijuana Legalization Lobby

If the findings of Professor Fried and others are accurate, then society is confronted with the reality of an inter-generational incompetency caused by smoked marijuana. A population with widespread addiction to hashish, even without the spread of addiction from heroin or cocaine, or alcohol, is a disabled population. In any society where the children and teenagers cannot focus their attention, they might be able to perform boring or low-skilled jobs, such as fast-food service, or running a microchip computer. But their "will," that is, their energies and curiosity to look outside their infantilism, is sapped. These young adults will not have the interest, or the attention span, to develop the economic and cultural well-being of the country in which they are citizens.

But this egregious outcome is exactly what motivates the pro-pot lobby that is pushing the legalization of marijuana today. Their legalization agenda is based on the "India model," an elaborate tax system that the British imposed on the population of India in 1895, in the height of the era when "the Sun never set on the British Empire."

A brief look at the history of how the British Empire used drugs to subjugate populations, and at the same time make easy fortunes, makes it clear that while the colonialists wanted to destroy development and progress, their opponents fought to prohibit psychotropic drugs because of their desire for progress. The individuals and countries that fought to outlaw dope, recognized that a nation could not have industrial and social progress *and* rampant drug usage. Progress and drugs are incompatible.

In 1893, the British Parliament commissioned what turned into a nine-volume study on hemp-growing in India, then a British colony. The India Hemp Commission Report, which took more than two years to compile, was an elaborate justification of an extensive hemp (marijuana) tax system, and the continued subjugation of the coolie population by encouraging its use of ganja.

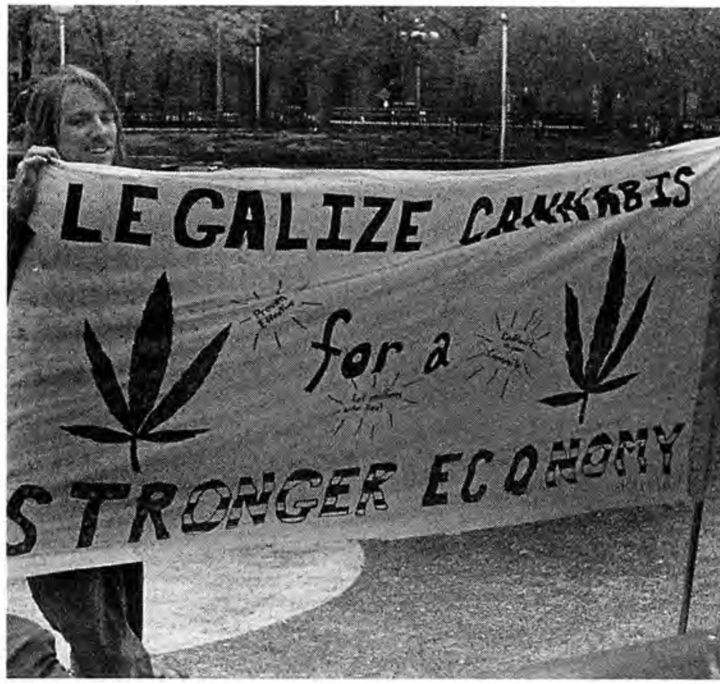
In the same way that the British opium trade in China was used in the Opium Wars of the mid-19th century to turn China into a drugged nation, incapable of acting in its own interest, the legalization of ganja was a convenient method for suppressing the population of India. The 1893 report is more than history. According to spokesmen for the National Organization for the Reform of Marijuana Laws, known as NORML, this Hemp Commission report is being used by NORML today as a model for its legalization argument!

It's easy to see why NORML is pushing this report, if we look at some of the testimony in the 1893 report, taken from pro-marijuana witnesses at the time, many of them plantation owners and tax collectors:

- Mr. Skinner, manager, Gorga Tea Company, Tezpur, Darrang, India, witness for the report: "The castes who use it most are Yoosoahe from Gaya . . . bricklayers from Calcutta, and of the jungle caste such as the Munhas and Sonthals. . . . I cannot see any harm in the use of the drug. All of those who appear to use it are good, quiet, and willing coolies . . . with no deleterious effects. . . ."
- Mr. John Phillips, tea planter, witness for the report: "I advocate no prohibition on ganja. . . . If prohibited, the health of our coolies would suffer, their lives would be sacrificed, and of course, discontent would ensue."

Walter Bird

The mother of today's international pot lobby: Baroness Barbara Frances Wootton of Abinger. For almost 60 years, Lady Wootton was a key figure in shaping New Age social policies, and her Wootton Committee report is the founding document of today's international pot lobby.



Stuart Lewis/EIRNS

The pot legalizers propagandize that marijuana relieves pain and stress, and has no harmful effects. What they don't tell you, is that when your brain goes up in smoke, you become a good coolie in their Brave New World.

• Rev. J.P. Jones, an Anglican missionary in Sylhet, witness for the report: "I have heard of men giving a few pence to buy ganja for boatmen and others where they require a little extra work from them."

• Deputy Commissioner of the port, Akyar, witness for the report: "It [ganja] is now brought in by the British India Steam Navigation Company."[35]

The next British report to take on an important role in the pot legalization movement is that of the first official commission in the world to explicitly recommend the removal of criminal penalties for marijuana possession—a 1968 committee of the British Parliament, chaired by the Baroness Barbara Frances Wootton of Abinger. The so-called Wootton Committee report is the founding document of today's international pot lobby.[36] Lady Wootton, a former Deputy Speaker of the House of Lords, may not be well known, but for almost 60 years she was a key figure in shaping the kinds of social policies that could turn the United States into a version of Aldous Huxley's *Brave New World.*

Wootton's top assistant on the committee, Michael Schofield, a Cambridge University social scientist, filed a "dissenting opinion" on the committee, calling for full cannabis legalization. Later, he sat on the governing board of the Legalize Cannabis Campaign in London. In the words of Schofield himself, the choice is between a moral society dedicated to industrial progress, and a brave new world. Schofield writes in his book, *The Strange Case of Pot:*

> There has been a growing emphasis on the cultivation of aesthetic and mildly hedonistic sensibilities. This is in line with current economic trends. Before long, working hours will become shorter and less important. The old puritan ethic which glorified work for its own sake will be less meaningful and leisure activities will become more important. . . . In such an atmosphere, the boundaries of permissible pleasure are extended and experimentation is encouraged. The use of cannabis to produce new sensory stimulation is a logical development of this ethic. . . . Of course there is no such thing as an ideal recreational drug. Cannabis like every other legal or illegal drugs falls far short of the ideal. . . . The ideal recreational drugs would make us feel relaxed and happy and act as a social lubricant. . . . Soma, the fictional drug in Aldous Huxley's *Brave New World* gave great pleasure harmlessly. . . . We have not (yet) come to terms with the idea of recreational drugs and so we cannot start to think out attitudes towards chemical aids to pleasure. Until we have developed a social philosophy, we are unable to make intelligent judgments about their use and abuse.

Today, the Brave New World is here. Increasing numbers of youth, and their parents, who were the "flower children" of the 1960s, suffer the effects of drug use, while the pro-pot lobby, and its political and financial backers, try to engineer more "soft" drug use as a method of controlling the "coolies" of the 20th and 21st centuries. The coherence of the current legalization campaign with the motivation behind Britain's past Opium Wars and the Hemp Tax are not altogether lost on the thinking public. Recently, for example, an op ed in the newspaper of the state of Hessen in Germany, by Dr. Jacqueline Kempfer, attacked the Social Democratic government of the north German state of Schleswig-Holstein for its plan to sell marijuana over the pharmacy counter.[37] Kempfer attacked both the anti-industrial Green party and the Social Democratic Party of Germany for eliminating nuclear energy in their states and hence lowering the living standard and creating unemployment. Then she charged that SPD Health, Work, and Social Minister Heide Moser was abusing her position as Minister for Health by leading the so-called hash initiative, stating:

> Maybe the hash experiment is the . . . solution for our actual problems. When we are filled with dope, unemployment seems much less, the Euro [currency designed by the European Union's Maastricht Treaty to replace the deutschemark] seems more valuable, our pensions are safer, and the taxes appear less.

The challenge worldwide is whether those citizens whose brains have not yet gone up in marijuana smoke, will fight to defeat NORML, financier-speculator George Soros, and the other organizations and individuals who are propagandizing for the legalization of "soft" marijuana for the coolies of the 21st century.

Karen Steinherz, a member of the LaRouche political association in Germany, writes on drug abuse and counterculture issues. Thomas Vissing holds a M.Sc. Engineering degree from the Technical University of Denmark, and is doing research on membrane physics.

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Coaxing Nature in Building the Powerful New Telescopes

by David Cherry

The world's largest laboratory for designing and building astronomical mirrors, is the Steward Observatory Mirror Laboratory, at the University of Arizona in Tucson. Its real mark of distinction is not its size, however, but the success of its director, Roger Angel, his close associate Nick Woolf, and their team, in coaxing nature to accomplish key tasks in the building of very large telescope mirrors.

As with all technologies, there are limits beyond which telescope mirrors can not simply be scaled up in size, without changes in design, and in fabrication methods. And yet, larger mirrors and the combining of mirrors are both crucial to progress in astronomy. The larger the mirror, the greater the resolving power for distinguishing fine detail, and the greater the light-gathering power for imaging faint objects. The principles of physics, therefore, have to be invoked in new ways to make larger mirrors, so that mechanical and computer fixes—technological epicycles, as it were—can be reserved for only the most intractable problems.

Lori Stiles/University of Arizona

The greatest advances in large telescope mirrors since the Palomar 5-meter mirror, are now being realized in the 8.4-meter mirrors for the Large Binocular Telescope. Here, astronomer Roger Angel (left) and technician Ned Franz inspect the first 8.4-meter casting on Sept. 11, the day the furnace was opened.

For decades after the design of the Hale 5-meter telescope for Mt. Palomar was finalized in the early 1930s, no one knew how to build a larger, more powerful instrument. The first ground-based telescope of new design was the Multiple Mirror Telescope (MMT)—built by the Steward Observatory in the late 1970s—using surplus spy satellite mirrors that had honeycomb structure to make them light. The MMT was an experiment in combining the light from several mirrors, instead of attempting to build a large, single mirror. Its six 1.8-meter mirrors, combined, had the light-gathering power of a single 4.5-meter mirror, and the resolving power of a 6.9-meter.

Another, much more ambitious project was the pair of Keck 10-meter telescopes on Mauna Kea in Hawaii, the largest in the world, conceived and built in the 1980s and 1990s. It was assumed that a large monolith mirror could not be made. Instead, drawing on an unrealized idea of George Ritchey, well known for his work on the Hale telescope, 36 hexagonal mirrors are mounted in a single steel frame, forming a composite surface of 10-meter diameter. Computer-controlled electronics continuously monitor and adjust the alignment of the 36 elements.

The various deeply aspherical curvatures required for the different segments were achieved by stressing each glass segment in a precalculated way with weights, and grinding and polishing them to the easily controlled spherical shape while stressed. When the stress is released, the segment relaxes to the desired curvature. The concept was developed by Keck's designer, Jerry Nelson of Lawrence Berkeley National Laboratory at the University of California. The Keck has a focal ratio of 1.75:1, the smallest achievable by this method. Greater stress would risk breaking the glass.

There are other projects for large telescopes now under way. The Very Large Telescope (VLT) being built by the European Southern Observatory for a site in Chile, will combine four 8-meter mirrors made by Schott and Sons in Germany. The Gemini project—a collaboration of the United States, Britain, and Canada—will put a single 8-meter telescope in each hemisphere, to give observers access to both Northern and Southern skies. And Japanese astronomers are building an 8-meter telescope called the Pleiades ("Subaru" in Japanese). The Gemini and Subaru mirrors are being made by Corning Glass.

The Most Advanced Approach

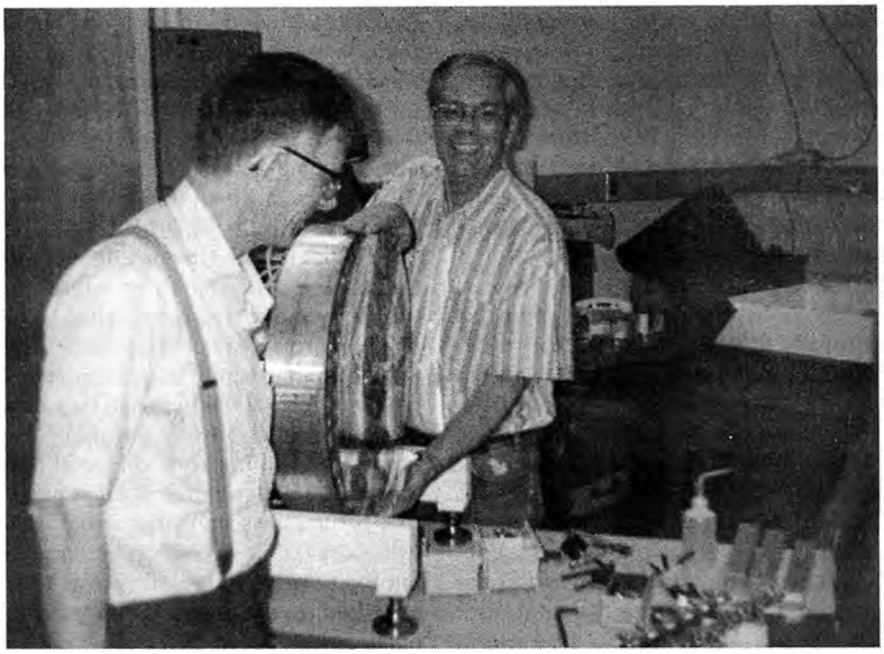
The most advanced approach to building large mirrors, however, is the one developed at the Steward Observatory Mirror Laboratory. The author visited the laboratory in June, after following its work for several years. There, the 8.4-meter mirrors for the Large Binocular Telescope (LBT) being built on Mt. Graham are being cast, ground, and polished. The LBT is a collaboration of the University of Arizona, the Italian astronomical community, a consortium of German institutes, and others.

The Mirror Lab's advanced designs and methods have already been incorporated in several mirrors smaller than 8.4 meters. The laboratory has finished a single 6.5-meter mirror to replace the 6 mirrors of the MMT, and is working on the first of two 6.5-meter mirrors for a pair of telescopes destined for Chile, the Magellan Project, a partnership of the Carnegie Observatories, the University of Arizona, MIT, Harvard, and the University of Michigan.

Combined with these projects is the Steward Observatory's work on adaptive optics, a spin-off of the Strategic Defense Initiative. Adaptive optics corrects the distortion arising from thermal changes in the entire air column above the telescope, distortion that blurs the image. In the Steward Observatory's approach, the corrections are made several hundred times per second by flexing the telescope's secondary mirror.

In addition to its work on large, ground-based mirrors—the subject of this article—and the associated work on adaptive optics, the Steward Observatory has been the source of a remarkable number of other advances in astronomical technology. One of these is a method to obtain the spectra of many stars or galaxies at one time, called multifiber spectroscopy: Optical fibers take the light from the various observed objects at the focal plane and transport it to positions along the slit of the spectroscope. It greatly increases the astronomer's efficiency.

Another is a method for measuring air convection on mountaintops that are candidate locations for telescopes. A third is the Near Infrared Camera and Multi-Object Spectrometer (NICMOS) installed in the Hubble Space Telescope early this year. There is an ultra-lightweight mirror technology for a much larger successor to the Space Telescope. And there is also a visionary proposal for a space-based optical interferometer to determine whether planets in other solar systems harbor life. It will be placed as far from the Sun's heat and dust as Jupiter.



The Steward Observatory Mirror Laboratory, with the encouragement of NASA administrator Dan Goldin, has made a prototype of a 6.5-meter mirror that will be only 2 millimeters thick, as a candidate for the Next Generation Space Telescope. Here Angel, holding the $50,000 prototype in his gentle hands, shows the author how the mirror rests on an array of 36 actuators.

Problem of Deep Mirror Curvature

One of the major problems in mirror-making is that of keeping the telescope housing from getting large. This is no minor consideration: Its solution may determine whether the cost of the telescope is within reach. As the mirror's diameter increases, the length of its tube—which holds the secondary mirror—also increases, requiring a larger housing. But the cost of the housing is greater than the cost of the telescope, and *increases nonlinearly as the telescope is made larger: housing cost increases as the cube of the telescope tube length.*

The key to the problem is focal ratio: the ratio of the focal *length* of a mirror (or lens) to its diameter. Focal *length* is the distance from the mirror to the plane where the image is formed at the focus of the mirror-paraboloid. (On cameras, the f-stop value is the focal ratio.) The telescope tube, therefore, becomes shorter if focal ratio can be made smaller.

Making the paraboloidal mirror surface more deeply curved, results in a smaller focal ratio (see figure, p. 76), but it is difficult and expensive to make such mirrors. It requires removing a great deal of glass from the disk (the "blank") by grinding, and to grind and polish in conformity with a curvature that changes so greatly from perimeter to center requires some new technology. It took 13 and a half years to grind and polish the 5-meter mirror for the Mt. Palomar Observatory, with a focal ratio of 3.3:1—not particularly short! Focal ratios have always been long, says Roger Angel, because no one knew how to grind and polish a mirror that is strongly aspheric.

If a container of water is made to spin, its surface assumes the curvature of a paraboloid, just the necessary shape for a telescope mirror. This well-known experiment inspired Angel to coax nature by casting the mirror in a rotating mold, so that most of the grinding for a deeply curved mirror could be avoided.

To grind and polish the steeply curved mirror, Angel invented, and his colleague Buddy Martin perfected, the stressed lap (see photo, p. 77). It was inspired by the technique used to make the Keck telescope's mirror segments: "Instead of stressing flexible glass piece by piece to achieve a severely aspherical surface, why not stress the lap and use a single, rigid piece of glass?" Angel asked himself.

For large mirrors, the lap is a motor-driven polishing pad on the end of an arm that travels back and forth from perimeter to center, as the mirror slowly rotates beneath it. The *stressed* lap changes its shape through a system of tensions, as it goes along, under computer control. Angel says: "It does that by looking up every millisecond and saying, 'Where am I?' and 'What shape should I have in order to fit the paraboloid?' And then the computer changes the actuators to give it that shape." The Mirror Lab ground and polished its first 6.5-meter mirror (focal ratio 1.25:1) in 4 years, while refining the stressed lap technology. The second one, also 1.25:1, will take only about 18 months.

The largest mirror currently being made in the Mirror Lab—the first of two 8.4-meter mirrors for the Large Binocular Telescope—has a focal ratio of 1.14:1. The 1.8-meter mirror already finished and functioning in the Vatican telescope on Mt. Graham, has an astonishing focal ratio of 1.0:1. These are ratios beyond previous imagining. The focal length of the Large Binocular mirrors is therefore just under 9.6 meters (8.4-meter diameter × 1.14 focal ratio), while the much smaller Hale mirror's focal length is 16.5 meters!

The Thermal Problem

The larger the mirror's diameter, the more it loses rigidity, unless it is also made thicker. But greater thickness imposes its price. The time required for the mirror to adjust to changes in the temperature of the air becomes intolerably great: So long as there is a temperature difference between the mirror and the air, thermal waves will rise from the mirror's surface (convection), just as they do from hot pavement on a sizzling day. This disturbance of the air above the mirror makes the image fuzzy.

How can a thin mirror be made rigid? The design of the Palomar mirror sought to address the problem by using a waffle-plate design—a 4-inch-thick faceplate with 4-inch ribs sticking out in back. The ribs didn't make it much stiffer, however. After Palomar, the Soviets built a 6-meter mirror that is 2 feet thick, and very rigid, but it takes several days to change its temperature, so it is always operating with convection.

The Multiple Mirror Telescope (MMT) dealt with this problem—and the problem of the long telescope tube—by mounting six smaller (1.8-meter) mirrors in a common frame. The light from the six mirrors is brought together to form a single image by series of small mirrors. The bending of the frame is continuously monitored and corrected by electromechanical push-rods behind the secondary mirrors. This technology is now common for correcting the shape of large mirrors as they are tilted up and down in the gravitational field.

Equally important, the MMT brought to astronomy the egg-crate honeycomb design for keeping mirrors thin: Its mirrors, made originally for use in space, have ribs of glass welded together piece by piece with a torch; they are then placed between the front and back plates, and the whole assembly is heated to the point that the pieces fuse. The honeycomb design, unlike the waffle-plate, has a backplate (with ventilation holes), providing great rigidity.

A variation on the multiple-mirror idea is found in the two Keck 10-meter telescopes on Mauna Kea, Hawaii, the world's largest telescopes. There, 36 similarly sized, hexagonal mirror segments of 3-inch thickness form a single mirror surface, by being fitted into a steel frame. Alignments are maintained with push-rods. It takes about two hours for the Keck mirrors to change temperature, however.

Angel sought a solution to the thermal problem with greater physical simplicity than the Keck. But he also realized that what he calls the "brute force method" of making a honeycomb mirror, by welding and fusing pieces, could not be scaled up to 8 meters. "It would be hugely labor-intensive and very unsafe" to handle the pieces. His new idea was the casting of the honeycomb as a single piece: One had to cast the mirror with cores in place to form the honeycomb cells, and then somehow "remove the ship from the bottle."

The material for the cores was perfected by materials scientist Blain Olbert. The cores are made of a ceramic fiber similar to that of the tiles protecting the Space Shuttle from the heat of re-entry. They can withstand the casting temperature of 1,180°C, yet, after cooling, they crumble when water is blasted into the ports in the backplate. To keep the cores from floating up during casting, in response to 50 pounds of buoyant force, they have to be bolted to the bottom of the mold through the ports. Silicon carbide hardware is used for this purpose, because it does not soften at the maximum temperature.

In the case of the 8.4-meter mirrors, the resulting faceplate will be only 1.125 inches thick after grinding and polishing, while the entire disk is just over 3 feet thick (see figure, p. 74). It will take only 40 minutes to bring the mirror to ambient temperature using forced air ventilation, with one nozzle per cell.

The monolith honeycomb design is not only superior to the Keck, but greatly superior to the 8-meter meniscus mirrors (curved in back as in the front) currently being built for two other large projects, the Very Large Telescope (VLT) and the Gemini twin telescopes. These are solid mirrors, 6.5 to 8 inches thick. The VLT mirrors are made from glass ceramic poured into a spinning mold, while the Gemini are being made by fusing flat glass pieces together at the edges and heating the resulting sheet to the softening point over a convex paraboloidal mold. In both cases, the mirrors are then supported by a steel structure to give them rigidity.

It will take six hours or so for these mirrors to change temperature. They must therefore rely on precooling to the *predicted* night temperature (or below, if that helps). But the night temperature curve is not smooth and predictable. For fine tuning, there is even a scheme to use electrical current to heat the aluminized surface of the mirror, after precooling.

Because of their exceptional performance, simplicity of operation, and low cost, spin-cast honeycomb mirrors, finished with the stressed lap, are the technology of the future for medium and large telescopes. And no other path is known by which monolith mirrors may possibly be scaled up to diameters of 10 or 12 meters, or more.

INTERVIEW WITH ROGER ANGEL

The New Telescope Mirrors: Rigid Honeycombs with Deep Curvature

J. Roger Angel, director of the Steward Observatory Mirror Laboratory, was interviewed in June by David Cherry.

Question: Can you review which mirrors your lab has made, and which ones are under construction?

We made three at 3.5 meters, which are all finished and operating in telescopes. One is WIYN, giving consistently sharper images than any other telescope on Kitt Peak. WIYN stands for the universities of Wisconsin, Indiana, Yale, and the NOAO [National Optical Astronomy Observatory]. Then there is the Astrophysical Research Consortium of Princeton and the universities of Washington, Chicago, and New Mexico. Their telescope in New Mexico uses another of these mirrors. The third went to the Air Force—Kirtland Air Force Base, Phillips Lab, near Albuquerque. That is the lead telescope for the Air Force to develop the techniques of atmospheric correction—adaptive optics. We should start to see the first really good Phillips Lab results this summer.

So those three honeycombs were cast, ground, and polished in the Mirror Lab. They were cast in a spinning furnace, on the same turntable that the big ones are being done on now. And then Buddy Martin and I developed the technique of stressed lap polishing. In fact, the funding to develop that technique came through the Air Force contract to make the 3.5-meter for the Phillips Lab. These three have validated the concepts, both the technology and the use of the honeycomb mirror.

The 1.8-meter mirror we made for the Vatican Advanced Technology Telescope, using these same techniques, is unique in that we pushed the focal ratio to 1:1. Our success with this mirror allowed us to choose a focal ratio for the big 8.4-meter mirrors that is almost as small, 1.14:1, for enormous savings in building cost.

As for the big ones, we have now cast two blanks at 6.5 meters. The first of those, to replace the six mirrors of the Multiple Mirror Telescope, is now virtually finished. It is already polished to the point where in space it would make images quite a bit sharper than the Hubble Space Telescope. We've got a couple more months of polishing on that. When that's done, then the second 6.5-meter mirror, the first of the Magellan pair, will go to polishing on the front face. We have already done some work on the back. And then, the first of the biggest mirrors, the 8.4-meter mirrors, is now in the furnace, and it is getting a remelting of glass on the surface. That happens on Tuesday [June 10, 1997]. We have three big pieces of glass, and we foresee now at least two more, the second one for the Large Binocular Telescope and a second Magellan mirror.

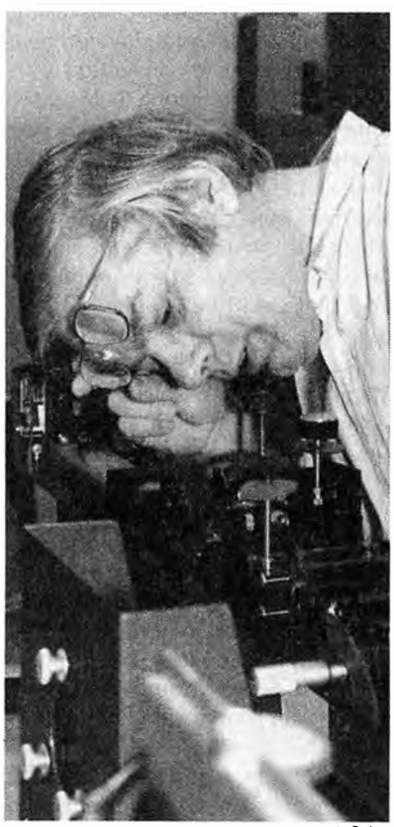
Question: How did you get started building mirrors and how were you funded initially?

The initial amount of money we needed was very little. We went to the local glass store and bought some window glass and bought some bricks from the potters' supply store. It didn't take many bucks to do the first experiments

Angel on Himself

Roger Angel is the son of an English chemist who had experience in the glass, plastics, and paper industries. He says of himself, "I went to a government-funded school, but one that drew the better students from the 11-plus exam. Then I went to St. Peter's College, Oxford, and studied physics as an undergraduate. I started graduate school in physics at Caltech in 1963, and then I decided to finish graduate school back at Oxford.

"After finishing, I was at Columbia University for five or six years. I taught physics and did X-ray astronomy, which involved launching sounding rockets at White Sands. Then I started to do mountaintop astronomy, and I would come out to the McDonald Observatory [University of Texas] mostly, but to the University of Arizona as well. Then I came here to Arizona in 1974." Angel is a Fellow of the Royal Society and a MacArthur Fellow. He recently became an American citizen.



I. Stiles

Roger Angel at work on a laser for adaptive optics.

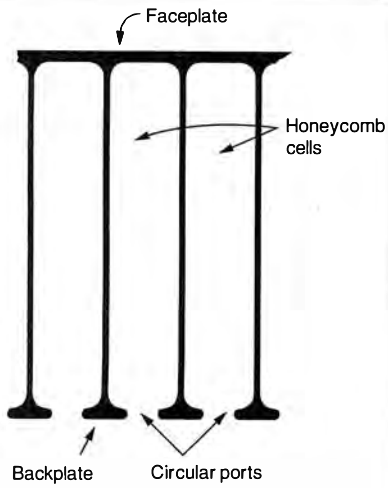


Figure 1
HONEYCOMB MIRROR STRUCTURE

How can nature be coaxed into providing both rigidity and light weight in a mirror that is 8.4 meters in diameter—more than 9 yards? Angel observes the universality of the ribs-and-surfaces combination for lightweight rigidity in both nature and artifice, of which the bees' honeycomb is one example. Another is the structure of bird bones, with their surfaces made rigid by a foam structure within. And there are man-made structures like airplane wings.

The sketch shows the honeycomb structure of the mirrors being made at the Steward Observatory Mirror Lab, in cross section.

on how you might form glass. As for the larger question of origins, there was a meeting in 1980, when Geoffrey Burbidge was director of the National Observatory [NOAO], looking ahead to the possibility of building big telescopes. It was this meeting which was one of the pivotal points in the thinking about big mirrors.[1]

Even earlier, there were two things that got me going. One was the 1980 decadal report on astronomy, an effort sponsored by the National Academy of Sciences that looks to the next decade, and is concerned with where the agencies like the National Science Foundation and NASA should be putting their resources. In the decadal report—and I was part of the study groups for that at the end of the 1970s—the issue of looking ahead to big telescopes was on people's minds. This meeting partly consolidated some of those thoughts of where we might be going. And up to that point, I wasn't involved in telescopes at all. I had done a lot of instrument making, but at this point, I began to think about ways to make the next generation of telescopes.

The other source of inspiration was the Multiple Mirror Telescope [MMT]. It had just come on the air at that time. It was revolutionary in many ways, using surplus spy satellite mirrors that were much lighter than typical big mirrors. We discovered that, as a consequence of their lightness, they made better images, because of their lack of stored heat. Nick Woolf, in particular, began to look at the problem of what the next generation of telescopes could look like, and how we could use this advance that we'd seen in the MMT of making better images.[2] And that led to the idea of making bigger mirrors that would have the same kind of lightweight structure.

The solid mirrors, particularly as you make them bigger, get thick and heavy, and they store heat. And that means during the night, they tend to give off heat from the surface. The convection—it's the same as the shimmering that you see over the desert during the day, as an exaggerated form of it—even a small amount of heat, even a 1°C difference between the mirror and the air, can give off enough shimmer to spoil the image. And so we realized that honeycomb mirrors that could be ventilated to get out the heat, would have a fundamental advantage.

The other advantage that got us going in making honeycomb mirrors was their stiffness. That is, for a given mass of glass, you can make something much stiffer if it is in a honeycomb form, instead of a solid slab. And if you think about it, the mirrors that we are planning are as big as spinnakers on sailboats, and have to operate in a similar amount of wind. And they have to maintain their surface accurate to close to a millionth of an inch. Well it doesn't take much wind to blow those mirrors out of shape. So stiffness is at a real premium, not so much for bending under gravity—we can deal with that—but bending with the wind.

I like to give the example of medieval cathedrals, which are perfectly designed to withstand the force of gravity. All of those flying buttresses and columns are designed so that the weight of the stone is holding the structure together. And you can use that principle to build very large structures, as they did in early medieval times. But you cannot design a structure both to resist the force of gravity and the force of *wind,* which can come from any direction. And so cathedrals taller than 140 feet don't exist—because they blew down in the wind.

It is a very similar situation with telescope mirrors. We can design them almost perfectly to resist the force of gravity, which also can bend them. But that is a predictable force, so you can design against it. But the wind force can come from any direction and is variable. The only way to design against that it is to have rigidity, and that is a fundamental advantage of the mirrors that we are making.

Question: Let's return to the matter of mirrors storing heat and producing convection in the air above them . . .

But there are also such effects from the building, and one of the things that we've realized is that big, heavy, steel buildings can also be very bad in that *they* store heat, and that takes time to come out.

Question: The Very Large Telescope being built by the European Southern Observatory, and the international Gemini telescopes—these are to use 8-meter diameter mirrors that are solid, 7 or 8 inches thick. However, they are not thick enough to be rigid, and *too* thick to respond quickly to changes in air temperature. What do the makers of the VLT and Gemini mirrors expect as a thermal time constant, the time required for the mirror to adjust to a change in ambient temperature?

Their thermal constant is a number of hours, and they are hoping to get around this, to get the mirror to the right temperature. The European Southern Observatory is going for a very elaborate forecasting and precooling of the VLT mirrors. There is some hope that by making the mirror actually colder, that these effects will not be as bad as when it is warmer than the air, although that is still not really known. It depends on how the wind picks up the air at different temperatures at the surface.

The Gemini folks are planning to over-cool the mirror and then pass an electric current through the reflecting layer and warm it up locally, until it is the same temperature as the air. So there are ways that are hoped for to get around the problem of the solid mirrors.

Question: What is the thermal time constant that you have with these honeycomb mirrors?

It is about 30 to 40 minutes, and so the mirrors will follow well enough the changes in the temperature of the air. The proof of the pudding with the mirrors that we've made is that they make gorgeous images. In particular the WIYN telescope on Kitt Peak is making images as sharp as any telescope on the Earth. In the past, it was believed that you wouldn't make good images on Kitt Peak because it is not particularly high, and it is in the middle of the desert. But the point that we have been making all these years is proven true by a recent, magnificent image of the Crab Nebula obtained by the WIYN telescope: That is, if you avoid these thermal imbalances that cause local convection, then you can get very good images.

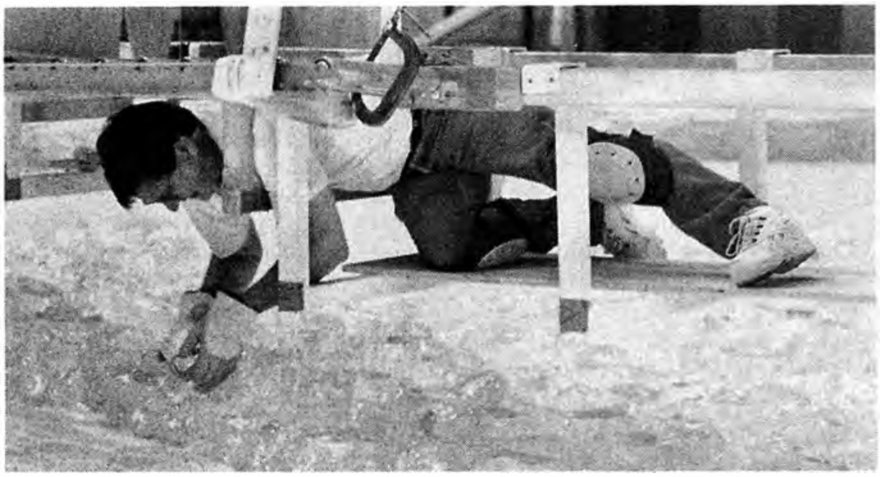
Question: How are the VLT and Gemini projects addressing the rigidity problem?

The rigidity problem for the VLT is, I think, more fundamental than the thermal problem, in the sense that they have at least hope of getting the thermal imbalance reasonably under control. They are using more complex techniques, but there is some hope to do it.

The rigidity is a fundamental problem. The only recourse the VLT has against the effects of wind, is to measure how the mirror has been distorted by the wind, and correct it with pushers. And so they will continually monitor star images, measure the bending of the mirror, and make the correction. That cycle of correction will occur every 40 seconds.

So they have realized that the mirror simply isn't rigid enough to hold its shape on its own. They get some rigidity by pinning the mirror to the steel behind it, but the steel changes shape all the time, so that doesn't work for very long. So on time scales of longer than 40 seconds, they have to resort to measuring the error and fixing it.

And that, I think, is the fundamental difference. We are sufficiently rigid so that the wind does not bend the mirror



John Florence/University of Arizona

Technician Rex Barrick loaded 21 tons of glass chunks into the mold for the first 8.4-meter mirror, in January. The glass is an inexpensive borosilicate variant like Pyrex, called E6, made with great uniformity by the Japanese glassmaker Ohara. The molten glass runs down between the cores (visible in lower left) to form the walls of the honeycomb cells and the backplate. After casting, the cores will be removed in pieces through the ports in the backplate.

out of shape. We don't have to continually check its shape. Of course, we know what gravity does exactly, so as we point through the sky, we can program in the forces on the pushers to be correct.

Question: Do those comments about the VLT also apply to the Gemini telescopes?

Yes. I got into all this just recently because I was reviewing how these projects are doing. So I can understand, from what has been written in the literature, how the VLT intend to overcome the wind. I am still not sure how the Gemini mirrors will work. They have a sort of second mirror of steel, which weighs 40-some tons, directly behind the glass mirror, and that second structure is somewhat isolated from bending by the motion of the telescope. I think their plan is to reinforce the glass with this steel structure.

Question: What do you mean by "isolated from bending by the motion of the telescope"?

As the telescope tracks objects through the sky, it bends. It is an enormous, heavy structure, and it bends enough so that if you pin the mirror to that structure, then it would very soon distort the mirror. So there is an intermediate structure, which is picked up on at three points. You can't bend something if you pick it up at three points; you can only hold it in position. So, as I understand it, they have this 40-ton steel structure behind the glass that isn't bent as the telescope moves, and that reinforces the glass.

Question: Turning now to the problem of obtaining a deep paraboloid, can you explain how the stressed lap works?

We use it to both grind and polish. Using a method developed by Buddy Martin, the edges of the lap's working surface are increasingly pulled up as the lap goes toward the center of the mirror; that is, as it goes toward the part that must be made more steeply curved.

The steps of making the parabolic surface are these. First, we spin the molten glass, so that it is roughly formed into the parabolic shape. It takes on the right shape to within a millimeter or two by the spinning. Then we machine the surface with diamond tools, and that gets the surface to within maybe a thousandth of an inch, or 50 microns or so. That's just like a giant lathe, and the tool is under numerical control to cut the right shape.

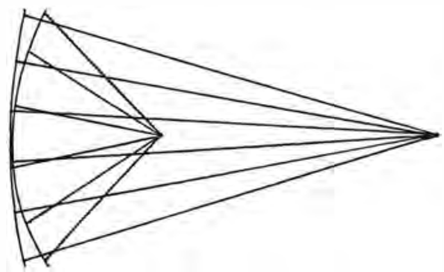
Question: It is not configured like the stressed lap.

No, this isn't a lap. It is a big spinning wheel with diamond embedded in it. It is a machining process. Then the stressed lap is used with loose abrasive of different grit sizes, starting with coarse and going to fine grit. At this stage, it doesn't reflect optical light, but it reflects infrared, and by using infrared measurements, we get the surface accurate to a micron. In the final step we switch to optical testing and the hard pads on the lap are replaced with pitch, a conforming material. We use the very traditional polishing techniques with pitch and rouge, or something very similar to rouge. We then control the shape down to an rms [root mean square] of about 20 nanometers.

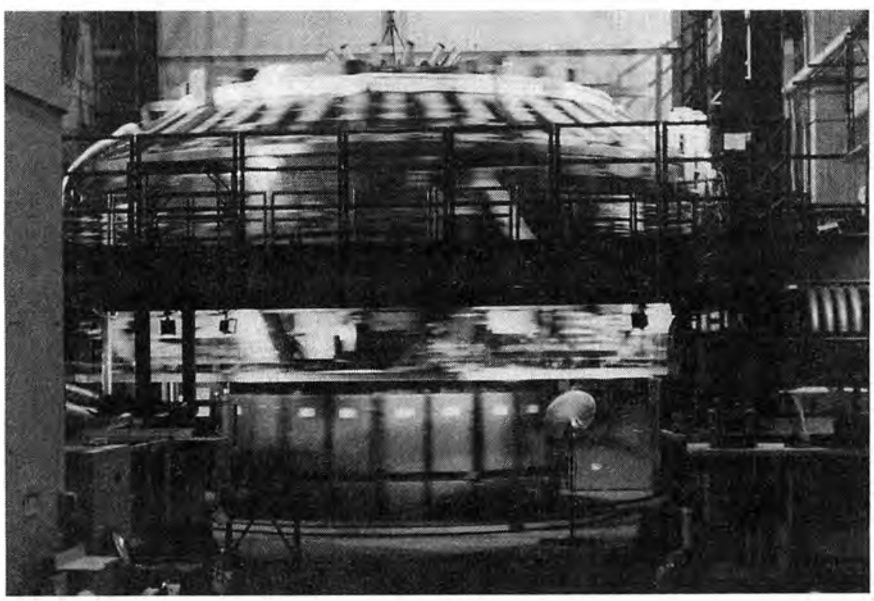
There is no difficulty in making glass shiny. The trick is to make it to the geometrical shape that you want. The problem with these deeply curved mirrors is that their surfaces are not even close to spherical. The traditional process for polishing optics, which goes back to the Middle Ages, involves rubbing two surfaces together; the natural consequence is to produce spherical surfaces. That's very easy to do, and almost every piece of optics that you see is made from lenses whose surfaces are polished spherically. Sometimes you see exotic optics with aspheric surfaces, which can be very powerful tools, but are very difficult to make.

By far the most aspheric surfaces that anybody has made are the ones that we are now making. The stressed lap technique is exquisitely developed to make very deep aspheric surfaces.

Figure 2
DEEP MIRROR CURVATURE



To make a telescope compact, make its paraboloidal mirror steeply curved. Here, two paraboloidal surfaces—represented in cross section—have the same diameter, but different steepness, producing focal ratios of 0.6:1 and 1.7:1.
Even though a secondary mirror catches the light before it reaches the focus, and folds it back through a central hole in the primary mirror (to come to a focus behind the primary), steep mirror curvature makes a crucial contribution to telescope compactness.



University of Arizona

Instead of laboriously grinding a flat surface to get a deep paraboloid, why not employ the laws of nature to achieve this shape? The furnace, mounted on a turntable, spins, and the surface of the molten glass becomes a paraboloid. A speed of 6.81 rpm produces a focal ratio for the Large Binocular mirrors of 1.14:1. The turntable drive has typical deviations of ± 40 millirpm.

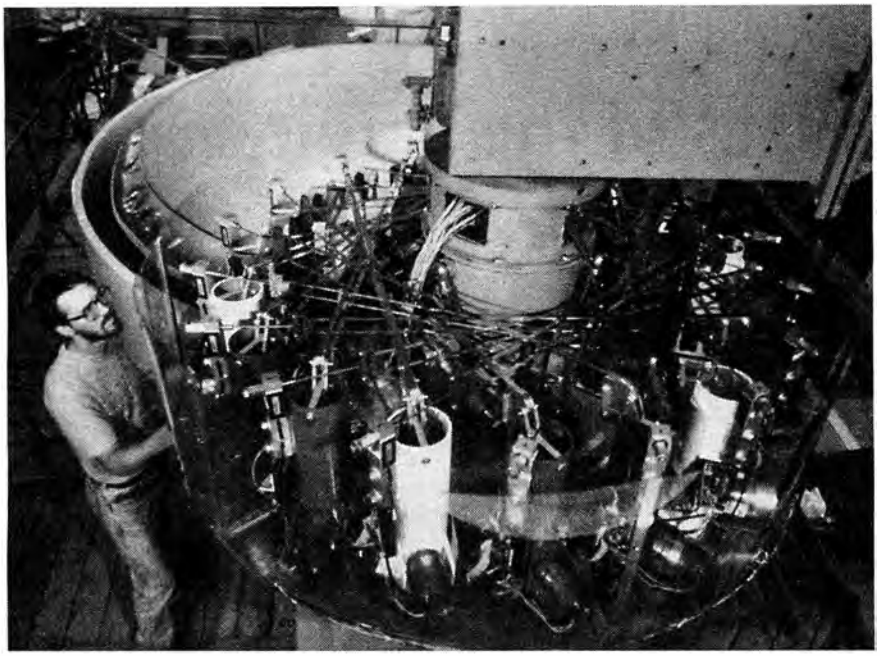
Question: Earlier, you mentioned a proposal of yours for the Next Generation Space Telescope, which seems to be going forward with NASA. What is needed in a Next Generation Space Telescope, and what is this proposal?

People are very excited by the results from the Hubble Space Telescope and it has had an enormous impact on astronomy worldwide. We can see that in about a decade, the Hubble will probably wear out. The last service mission is planned for 2002. Spacecraft do eventually wear out. We are at the point now where planning for a successor to the Hubble is something that we need to do very seriously.

The general scientific directions that have been identified for where you would like to take the next step, are to make a telescope that is bigger, but also more directed toward infrared wavelengths. That is because, if we want to follow up the Hubble's discoveries of the formation of galaxies, where we are looking back to the early history of the universe, we are looking back to a time where the cosmological redshift is very large, and therefore wavelengths which were emitted as visible light, we now detect as infrared light. So if we want to do the same kinds of things that we do in the local universe with optical telescopes, we need infrared telescopes to look at those same phenomena early on, that is, in the distant universe. Because of heat (infrared) emitted by Earth's atmosphere, the environment of space is very, very much better for making these infrared observations than what we can ever hope to do from the ground.

But to make sharp images in the infrared, you have to have big mirrors, 6 or 8 meters in diameter. Here we are, we have just *made* a 6.5-meter mirror, which would do a perfect job in space. But it is heavy, and nobody has a vehicle, a rocket, that would take up a telescope that could accommodate the heavy mirrors that we have made. So we want to take the same technology and see how to turn it toward making a 6- or 8-meter mirror that weighs a tenth or less than the ones we have made.

We have figured out a method to do that. We make a sandwich of which the mirror glass is only the top layer, before we start the grinding and polishing. The bottom layer is a heavier piece of glass, and the two are rigidly attached by a



Lori Stiles/University of Arizona

Astronomer Buddy Martin with the massive lap for grinding and polishing that he perfected. The rotating lap, mounted on an arm, moves in and out on the mirror, as the mirror slowly rotates beneath it. What makes this lap different is that it changes its shape as it goes—up to a thousand times a second—under computer control, to conform to the severe paraboloidal shape required. The mirror surface can be made more accurate than any ground-based telescope can take advantage of.

Angel comments, "We put posts around the edge of the lap, and then there are 'strings' connecting posts across the lap. We change the tension on the strings and that bends the lap. The question was, how to string the lap so that the correct shape changes would result. Buddy figured out that the strings should connect the posts in equilateral triangles."

layer of pitch. When we have gotten the surface to the exact, millionth-of-an-inch precision, we can warm the sandwich to melt the pitch and slide off the top layer—that is, the mirror. So with that kind of technique, we can use our present manufacturing methods for deep curvature, to make a mirror that may be only 2 millimeters thick. That, obviously, is an enormous reduction in weight. A 6-meter mirror 2 millimeters thick weighs about 300 pounds, compared, say, to the Hubble 2.4-meter mirror, the glass of which weighs over a ton.

Question: In space, you don't have gravity and you don't have wind. You still have to hold the thing rigid, but it is much easier.

Right. In some respects, making telescopes for use in space *is* a lot easier. At 2 millimeters thick, it is almost like a piece of paper, so, particularly in this very large size—we talked about a spinnaker earlier on—this mirror would bend like a sail. So in order to hold its shape, we attach it to a rigid, lightweight structure of carbon-fiber composite, which is the most efficient, lightweight material that we have. It is a lot stiffer than steel. Then the attachment points are made with screws whose lengths can be adjusted so that after we get into the space environment, and after it has cooled down, which will cause the structures to distort, we can fix everything up by turning the screws to get the image right.

The prototype that we built and tested for the accuracy needed for the Hubble's successor, used carbon-fiber composite, 2-mm thick glass, and the screw adjusters, and worked extremely well. It was half a meter in diameter, but it had the same thickness of glass and the same density of screw supports that we would use in a big mirror for space.

So we have opened an interesting possibility now. The previous thinking had been that a big mirror would have to be unfolded like a flower in space. It would have to be deployed with mechanisms. That was partly because nobody knew how to make a piece of glass—a single mirror—that was big enough. So they said, well, it is going to have to be made of small segments of glass that fit together. And we only have small rockets. So why don't we fold it all up and set them out when we're in space?

That's a process that delights engineers, because of the challenges as to how it would do that without getting stuck, but the hearts of astronomers are more enthused with something that is built complete and tested, and could be launched into space in one piece.

The weight of the telescope that we are thinking about is so little, that it is well within the bounds of a lot of potential rocket vehicles. But at the moment, no vehicle has the diameter capability. We are talking about a telescope that weighs 2 tons. Even though it is much bigger than the Hubble, the new technology of lightweighting would let the whole telescope be much lighter than the Hubble. But it would need to be launched in one piece. It would need a shroud on the front of the rocket that is 7 meters in diameter. At present, shrouds get up to about 5 meters. It would involve some development to make one big enough.

The NASA rockets—the Atlas and Titan rockets—are fairly skinny rockets. The main cylinder is 3 meters in diameter. If you put something that is 7 meters in diameter on top, it will be difficult to control. But the Proton and the Ariane-5 and H-2 rockets are in the 4.5- to 5-meter diameter range. So there are, in Europe and Japan, rockets with the authority to carry something 7 meters in diameter on top. In the United States there is a program to develop bigger rockets, the ELV program, which might result in a suitable rocket. But as the Hubble's successor is almost certainly going to be an international project, it might be a very nice avenue for Europe to participate in it by providing an Ariane-5.

Notes

1. The proceedings of this meeting are *Optical and Infrared Telescopes for the 1990s, Tucson, Arizona, 7-12 January, 1980*, edited by Adelaide Hewitt (Tucson: Kitt Peak National Observatory, 1980).
2. Neville Woolf, 1982. "High Resolution Imaging from the Ground," *Annual Reviews of Astronomy and Astrophysics*, Vol. 20, pp. 367-398.

INTERVIEW WITH JOHN M. HILL

Humble Beginnings of the Large Binocular Telescope

Astronomer John M. Hill is director of the Large Binocular Telescope project at the Steward Observatory Mirror Laboratory of the University of Arizona. He was interviewed in June by David Cherry.

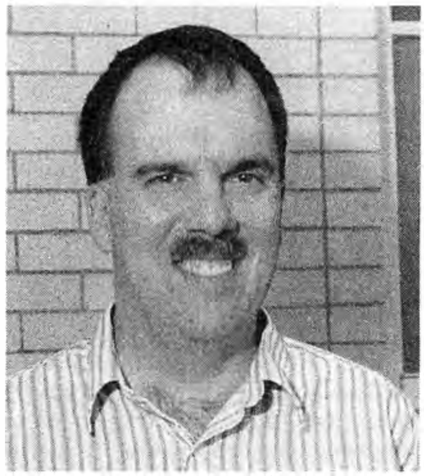
Question: What led to the concept of a large telescope that would be binocular?

The idea that led to the Large Binocular Telescope [LBT] came from the Multiple Mirror Telescope, with its six mirrors on a common mount [MMT]. Our experience from the early 1980s, was that you could adjust and align the MMT mirrors so that the light was phased—that is, acted like a single 6.9-meter telescope in terms of resolving power—and that you could see the fringes that corresponded to the diffraction pattern of the six mirrors. It was that experience that led to the design of the LBT as a binocular telescope. We had learned that it was possible to build a telescope where you aligned multiple mirrors and got a diffraction-limited image, and the combined mirrors corresponded to a larger aperture than that of the individual mirrors.

The prevailing wisdom at the time, was that it was very hard or impossible to do, but because we had *seen* it on the MMT, we knew that it was perfectly workable.

How did the making of mirrors at Steward Observatory begin?

It was August of 1980, and I had just come back from summer vacation in Pennsylvania. Roger showed me two pyrex custard bowls that he'd melted together, back to back, in his garage. He told me that this showed we could make—I think at the time he said 7.5 meter—honeycomb mirrors out of pyrex, and not knowing any better at the time, I said: "Okay, sure. Let's do it" [chuckles]. So we went out and got some parts for a furnace at the local potters' supply store, some insulating bricks and electric heaters, and we put together a little furnace, and started melting glass into honeycomb structures. The original ones we were making by fusion, not by actual casting, but by cutting pieces of glass and fitting them together like egg-crates, and then fusing them. Then as we evolved the technology, it became casting.



Kristin Giordano/University of Arizona

John M. Hill is responsible for mirror casting at the Steward Observatory Mirror Laboratory.

Question: What was the purpose of the pyrex custard bowls experiment?

It was just to show that you could make satisfactory structures by fusing pieces of this kind of glass, borosilicate glass—pyrex. The original idea was to make fused structures like the MMT mirrors, but in borosilicate, which is easier to do and cheaper, than in fused silica.

Question: Why is it cheaper?

Because the material is cheaper. In this case you could go to K-Mart [chuckles] and buy more. Also because it fuses at a lower temperature, and so the furnace technology required to fuse it is much simpler than the high-temperature furnace needed for fused silica.

In that same time frame, the MMT was just coming on line, which has honeycomb mirrors that were surplus from an Air Force satellite project in the 1960s. So they are made of fused silica, but they are made of an egg-crate honeycomb fused together. And they were put in the MMT because they were cheap, but in fact they turned out to give exquisite images, and one of the reasons was that they were lightweight and they could follow the nighttime temperature as the air on the mountain cooled, and so you didn't have any thermal-induced seeing coming from the mirrors. People very quickly saw that the MMT made much better images than they really expected it to make, when they designed it, just because of those honeycomb mirrors. And that was how this all got started.

Question: So what caused you to shift to the idea of casting?

We made some very nice little honeycomb structures by making egg-crate pieces and fusing them, but we were limited by the size of the biggest sheet of plate pyrex—or any kind of borosilicate—that you could buy. So we started experimenting with fusing the edges together. But we couldn't get a very good bond, so we kept trying at hotter and hotter temperatures. Pretty soon we noticed that if you melted the whole thing, that sure enough, the edges fused together just fine. And then we asked ourselves, why even bother with fusing the egg-crate pieces, when you can just make the whole structure in a mold?

So a week after that—it must have been in the spring of 1981—we cast the first honeycomb. And already we had come upon basically the right material for the cores—the alumina-silicate-fiber mix.

Question: Where is this material obtained?

It's industrial. It's used in the steelmaking industry for insulating nozzles and steel furnaces. There are a half-dozen companies that make it into specialized shapes, and so you just have to

Jim Slagle

The Large Binocular Telescope under construction on Mt. Graham, near Tucson, Arizona. Engineers Buddy Powell, director of the telescope project (right), and John Ratje, site manager (left), flank the interviewer. The architect's sketch of the completed structure is inset. The project is succeeding, despite years of frivolous legal suits, sabotage, death threats, and threats to smash the mirrors, coming from the radical environmentalist camp.

call them up and give them a drawing of what shape you want them to make. A lot of the same furnace technology we use had prior applications in the steel industry and other sorts of manufacturing processes. So almost all of our stuff comes from back East in steel country.

Question: How did you happen upon this material? Was it looking through catalogs and reading the specs, or feeling the stuff?

I can't say that I remember. Some of both, perhaps. You can buy insulating board and blanket, the same material that insulates the furnaces in the potters' supply store. It must have come through that. And then you find the company that makes that, and then they make the other shapes as well. The formulation that we use now is much more high-tech and precise than what they sell at the potters' supply store, and that's where you get into having a materials scientist, somebody who works out the details so we can optimize the strength and the reliability of the material.

Question: And so the materials scientist on your team, Blain Olbert, developed a formula which he then gave the manufacturer and had them make it to those specs?

Well, its more complicated than that. They make some, and then we tell them what is wrong with it, and then they adjust their recipe for the mix of fiber and binder, and so on. Because you want a mix that doesn't interact too much with the glass, yet has good strength at high temperature, yet is not so strong that you can't get it out of the honeycomb after casting. It's a tricky mix of properties to get just right.

Question: Adaptive optics is being developed to correct distortion from thermal changes in the entire air column above the telescope. How rapidly do you think adaptive optics will be put in place in the Large Binocular Telescope?

At the moment, the progress on the prototype adaptive secondary mirrors for the MMT—the people at Arcetri in Italy who are working on the LBT are working on that project also—the prototypes are going so well that I'm thinking that LBT will not have a conventional secondary mirror—that it will go immediately to the adaptive secondary without the conventional step in between.

Roger's group, that includes Thermotrex [an aerospace technology company in San Diego] and the people here at Arizona, and various collaborations—that includes Italy—have been developing the technology on how to make an adaptive secondary. You have probably seen the thin glass shell we have made.

Question: The shell I saw was a prototype 2-mm thick mirror for the Next Generation Space Telescope.

But the adaptive secondary shell looks just like that. It's a multipurpose technology. And then Arcetri has the technology for the actuators that modify its shape by pushing it from behind. They have different prototypes that do different things—I don't track them all that closely—but they all seem to be working very well. And so I think LBT is just going to go immediately to adaptive secondaries.

Question: What was your own background before you became a student of Roger Angel in astronomy?

I had been an undergraduate in chemistry and physics at Geneva College in Pennsylvania, and then I came to the University of Arizona to study astronomy. I'd been working with Roger on another project, multi-fiber spectroscopy, in my first year of graduate school.

Question: Multi-fiber spectroscopy goes back that far?

The first fiber spectra were taken before I got to Arizona, using just one fiber on the Steward 36-inch on Kitt Peak. That was in about 1977 or 1978. And then my project in the fall of 1979 was to get a set of fibers and drilled aperture plates and put them on the 90-inch telescope. And so I think it was November or December of 1979 that we took the first multi-fiber spectra.

You only had to take multi-fiber spectra for about three nights before you realized that there had to be a better way than sitting there plugging fibers into a plate full of holes, gluing them into place, and then putting that plate in, while you got the next one ready. And that led to the idea of making the robots that eventually became my thesis project, the MX Spectrometer, where you had 32 fibers moving under computer control. Now almost every big telescope has some version of the fiber technology.

LEONARDO FOR YOUNG SCIENTISTS

The Seashell's Secret Revealed

by Richard Welsh

This is Part 3 of a series on the work of the Leonardo da Vinci Science Club in Leesburg Virginia, which conducted weekly classes from October 1996 through April 1997. The students were six- and seven-year-olds. Parts 1 and 2 dealt with geometry, optics, and the science of perspective. Here, we take up the idea, that to draw something convincingly, or to understand it in some other way, we are well served by discovering how to make it. This is especially true of certain geometric ideas, that we discover permeating the created universe.

R. Welsh

Members of the Leonardo da Vinci Club exploring nature's geometries, with the construction of Platonic and other solids.

This section of the Leonardo club started with one, apparently simple, idea and exercise: to make a snail shell out of clay. Over four weeks, we extended this idea into an exploration of the properties of cones and conic sections; the imagining and creating of solid shapes with no substance whatsoever; development of some of the useful and productive properties of rotational action; and having fun with the ubiquitous scientific process of making invisible processes visible. All of this follows the trail brightly blazed by Leonardo.

In the end, however, none of the spun-out activities compared, for fascination, with the first, simple rolling out of an amorphous lump of clay, and coiling of the resulting cone into the spitting image of a real-life snail. I believe this is because all of the derivative paths down which we wound, and many more not taken, were *implicitly contained in* that first exercise, and the natural shape that inspired it, giving to the shape and its creation, the same kind of intellectual and esthetic tension that, for adults, animates great art and drama.

Of course, the spiral form populates all the neighborhoods of nature, and has been reproduced in art and artifact for at least 20 millennia of human history and prehistory. (Specifically, we are concerned here with the logarithmic, equiangular, or self-similar spiral, rather than the Archimedean spiral. See Figure 1.) Some of you reading this, are familiar with mathematical treatments of such forms, and have perhaps created them with computer graphics; or, you may be familiar with books dealing with the geometry of natural shapes. But for now, put aside all your formal learning, which is more likely to get in your way, than help, in understanding the appeal of this project to young children.

A Planiform Start

We start with a small lump of a non-hardening modelling compound ("Sculpey" is one of the best for this purpose, respecting physical properties and non-stickiness, and can be bought in small quantities). Roll it out into a very long, thin cone. Then, beginning at the apex, coil the cone, as if it were a rope or garden hose. Voilà": a snail of "planiform" type, that is, all the coils lie in a single plane (see Figure 2). This is also the form of the much-illustrated chambered nautilus (Figure 3), the most commonly pictured exemplar of molluscan spiral (though the nautilus is a squid-like animal, rather than a snail).

In nature, however, very few snails, mostly land species, are planiform. The vast majority of snails—"sea shells"—drop their coils down the vertical axis of rotation as they grow. So, form a snail of that type (Figure 4). Young children, lacking the requisite dexterity, can coil the clay cone around a thin dowel or comparable solid axis, and then slide the dowel out. So: you have now created the plan common to most marine snail groups.

Good progress—but there are some 50,000 species of snail discovered to date, whose seemingly infinite variety of form you have just begun to explore (for example, Figure 5). Not surprisingly, you can (in principle) model all of these from clay, with but a few simple variations on the techniques you have used, so far. But before we look at these variations, let us return to the starting idea: what is it that makes this exercise pleasurable?

Start with the very real difficulty of representing a snail shell in art. If you look closely at a typical shell, you realize it is not so simple. For one thing, there is no obvious symmetry (unlike, for example, the atypical nautilus-form, which has a bilateral symmetry, when viewed from the top). Second, it cannot be built up from identical elements: The size of the coil, for example, keeps increasing as you progress from apex to aperture. Finally, the curve itself is not constant (unlike a circle); it is regular only in its *rate of change*. To bring out these difficulties, the class unit began with an assignment to choose a seashell from a proffered pile, and quickly draw it.

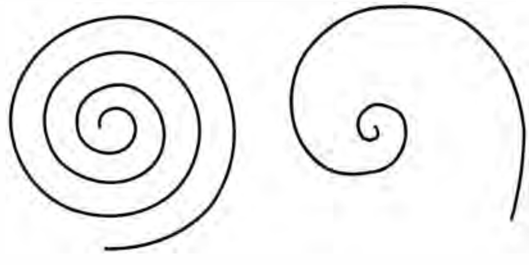


Figure 1
ARCHIMEDEAN AND EQUIANGULAR SPIRALS
In the equiangular, or logarithmic spiral, the rate of curvature changes much more rapidly than in the Archimedean: The farther you spiral out from the origin, the more distance outward is covered by each succeeding revolution.

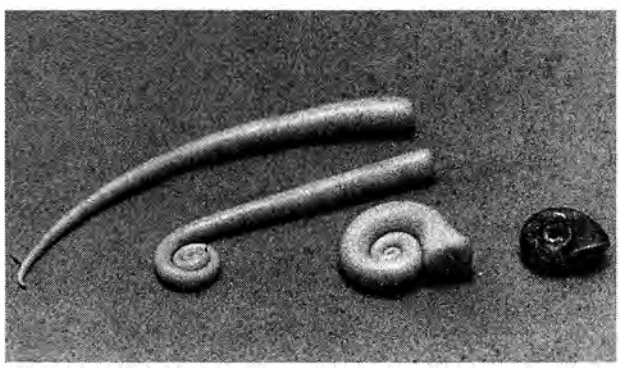


Figure 2
MANUFACTURING A CLAY SNAIL
Stages in the manufacture of a clay snail, and a natural cousin.

Now, these children show a normal range of sketching ability for the age. There was no possibility that any of them could produce an "accurate" drawing. It was emphasized to the children that such was not expected, but only that they should make a first approximation, so that after our promised scientific study of the subject, we could come back and have another go at it. The metaphoric purpose, was to establish for the children, the contrast between their "normal" mode of perception—of more or less taking appearances at face value—and the contrary emotion and intellectual potency that accompany *discovery of a principle*. That discovery is what we accomplished with the clay modelling exercise that followed.

Paradoxes

Thus, a paradox emerged: a "complicated" geometric form, difficult to draw or build up piece-meal, could be produced, suddenly, by two simple steps! In fact, the *single* action of rotation, performed twice: rotation of the clay lump into a cone (itself a double-rotation, but we did not develop that idea in this class), and rotation of that cone about an axis to produce the finished snail shell.

And perhaps a second paradox: I, a child, with few or no skills comparable to an adult's—still less, to the Creator's!—can make something which, so far as I can tell, looks like something real from nature, and a really beautiful something at that!

From here, we went in many directions, like Leonardo, repeatedly returning to explore old subjects from newly developed vantage points. One such direction was to explore cones themselves, divorced from their expression in snail shells. Another was to attempt an expansion of our "shell-creation" technologies, to discover those few variables, which in different combinations, could generate the plethora of natural species. In both of these, we kept going back and forth between the "abstract" (though enjoyable) geometry of cones, conic sections, and cone-producing processes, and the many examples of these forms and processes in nature and in technology.

Just making cones, as it turned out, was new to most of the children. Teaching them these techniques added some time to the unit, but also a new measure of delight, in the discovery that one could make a flawless, symmetrical solid from an ordinary piece of paper. One child's cone was very irregular, with its apex significantly off-center. Her frustration turned to amused pride, when the teacher whipped out one form of snail, a large limpet, that was similarly shaped: There! you have re-created the form of something real in nature; you have "invented" the limpet! (See Figure 6.) In this business, nearly any accident can be turned to profit, and should be, since "accidents" of this type simply reflect another, hitherto unaddressed, domain of reality—a different geometric property, a different species of creature, a different generative process.

Interplay Is Crucial

For Leonardo, as for us, this interplay of geometry, nature, and technology, was crucial: none stood by itself. For example, flight: the anatomy of birds, and relationship between the geometry of wings, sails, and other wind-harnessing shapes; the shape of the flow of air currents (and corresponding studies of water); the designs for machines either to mimic directly the flight of birds, or to use alternative principles discovered in the studies.

So, how about the other forms of snail shell? For this exploration, the students were given a diverse assortment of

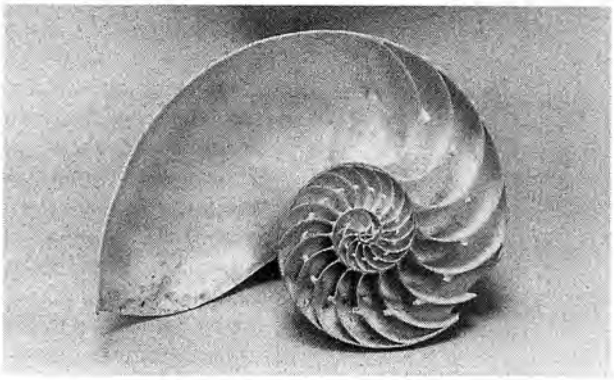
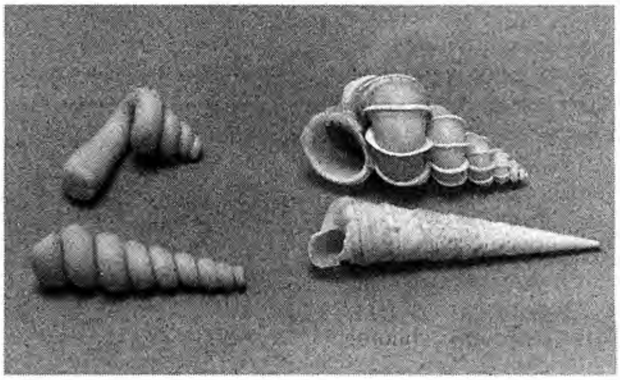


Figure 3
THE CHAMBERED NAUTILUS
In the familiar chambered nautilus, the shell is cross-sectioned to show spiral pattern. Contrary to some representations, the ratio of each succeeding whorl's radius to the radius of the preceding whorls, is not the numerical or algebraic golden section, nor is it true for the proportions of most other mollusk shells. The actual significance of the golden section conception, as emblematic of a growth function, is actually better grasped when approached as we did in the Leonardo club, that is, "grasped."

Figure 4
MANUFACTURING A LONG-SPIRED SNAIL
The long-spired snail is a creature inhabiting (or rather creating) an additional dimension to those utilized by planiform snails. Natural examples: a wentletrap (top) and a turritella.



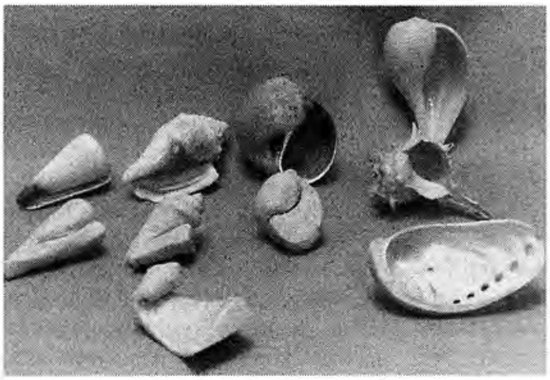


Figure 5
SNAIL SHELL DIVERSITY
A sampling of snail shell diversity, with clay imitations of a cone shell, a strombus, and a moon snail. The clay strombus is also shown partly unwrapped. Older children can explore further, to discover why the clay models are still only approximations, with crucial errors. It is not merely a question of accuracy, but of method of generation. For instance, a real snail does not start as a straight tube and then coil; the curvature of the coil is inherent in the growth. You will know the implications of this if you have ever made your own clothing.

seashells, with the task of reproducing these in clay. None came very close, being limited particularly by their insufficient dexterity. In discussion, however, they quickly grasped the notion, contributing their own insights, that it would not take too many variables to produce the many varieties of form. First, the cross sectional shape of the coiling tube: rather than a proper cone, circular when cut across, it might be closer to a rectangle, a triangle, or some shape of varying positive and negative curvature. Second, the acuteness of this "cone": Does it expand rapidly, as in a moon snail, or very slowly, as in a turritella? (See Figures 4 and 5.) Third, the proportion of each whorl (coil) that is overlapped by the succeeding whorl. Fourth, related to this, the tightness of the coiling, around the central axis of rotation. Such exercises in transformation were also dear to Leonardo, both in his anatomical and "character" sketches (such as his famous "grotesque" faces), and in studies of geometry and of materials deformation.

Having made their own, less complex, shells, and attempted the more difficult ones, the children became veritable connoisseurs, when offered a sampling made by the teacher (rough approximations of natural types), and were eager to uncoil them to their starting shapes (Figure 5).

Unfortunately, we have not been able to locate any drawings by Leonardo of shells, surprising as this may seem (though the lost portion of his manuscripts may amount to two thirds of the total corpus). We do know, however, that his knowledge of these creatures was more than passing. In his famous, pioneering, geological insights, regarding relationships of sea and land, and their various risings and fallings, he commented as follows, on the fossil marine organisms found on mountaintops:

"If the Deluge had carried the shells for distances of three and four hundred miles from the sea it would have carried them mixed with various other natural objects all heaped up together; but even at such distances from the sea we see the oysters all together and also the shellfish and the cuttlefish and all the other shells which congregate together, found all together dead; and the solitary shells are found apart from one another as we see them every day on the seashores" (from the *Codex Leicester*).

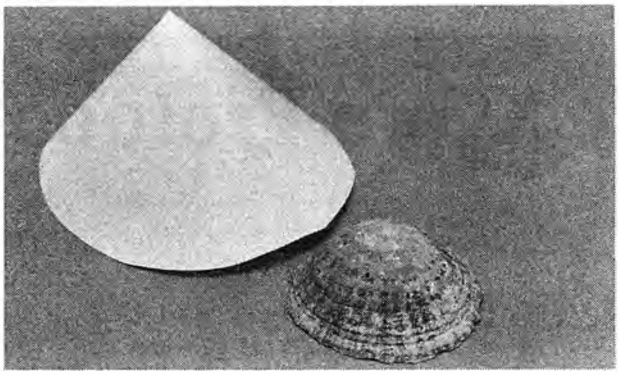


Figure 6
LIMPETS
Limpets in nature (a common form, adapted to surf-pounded rocks), and in paper (a happy accident).

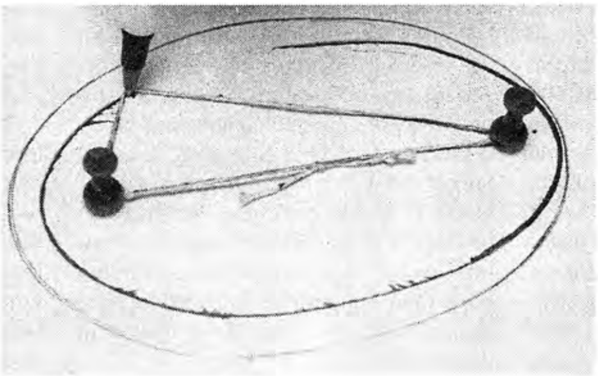


Figure 7
CREATING AN ELLIPSE
Making families of ellipses with string and push pins.

When we returned to cones as such, the children were given the challenge, to see how many ways they could make one. We had already done the basic curling of a paper semicircle; what other methods were there? One was to sketch a spiral, then cut it out. They readily discovered that by lifting the spiral from the center, the coils would dangle down to create an "air-conditioned" sort of cone. I had expected some protest at this change of rules, the cone's wall becoming discontinuous, filled in only by imagination. Being young children, they ignored my theory, were merely pleased, and spent a good bit of time exploring the lively springiness of their dangling conic spirals.

We made many other forays out from our home base of cones, including various approaches to clay construction, and the elegant, different, method of making a cone from a weighted string (swinging it around, like a pendulum tracing out a horizontal circle, while holding the top in a fixed position). We experimented with conic sections as such, producing them by slicing clay cones, and then by the string and push pins method to draw circles and ellipses. Were the children uplifted by the discovery that the same shape could be generated in two such different ways, as I had theorized they ought to be? If they were, they weren't letting on. They were quite happy to simply draw ellipses, especially when they got the idea of drawing ellipse families by keeping the string loop of constant length, and varying the distance between the foci (Figure 7).

Light Behavior

Finally, we returned to one of Leonardo's favorite subjects, the behavior of light, which the children had explored in previous sessions (see *21st Century Science & Technology,* Fall 1997). Our project, in this section of the club, was to *make cones* out of light! We began crudely, so as to take nothing for granted: a light bulb in a cardboard carton, shining out through a foil cone (narrow end inserted into a hole in the carton). The children took turns cutting the cone, by holding pieces of white cardboard in the beam, at various angles, to produce circles, and ellipses of different proportions. I asked them, then, if they knew of any uses for a light cone, or of other ways to produce it: flashlights, some realized. So, at that point, we began to use this more efficient device, taking turns drawing the ellipses produced on paper by the cut flashlight beam, and making circles grow and shrink on the wall (and on one another), as the cone was cut farther from or closer to its apex.

But one thing was still missing: in truth, we could not *see* the light cone. We knew it was there, by the indirect proof of the ellipses and circles cut from it by the wall or paper. For viewing the light cone itself, we needed the equivalent of a "smoke-filled room," a campfire, or a foggy night. This problem was solved in two ways: First, we blew on ashes in a cold fireplace, and burned some smoky incense in there as well; and finally, we created the equivalent of a "cloud chamber" such as is used in nuclear physics, to show the track of a subatomic particle that cannot be observed directly. The technique is old, and goes back at least to Leonardo, who used myriad forms of marker to chart the shape of fluid flows of air and water, such as millet seed, colored inks, and smoke. Our device was a handful of flour in a clear, tightly-sealed, plastic storage box, through one end of which we shone our flashlight. Thus, we made the invisible (which we knew to be there), visible for all to see: our cone made of light.

But still, as I realized only in retrospect, the children's greatest satisfaction came from inventing and manufacturing their own snails, the starting idea for the entire class section. Certainly, the discovery and mastery of a *principle of generation* is crucially at play here; is there more?

Defeat the Kyoto Protocol!

by Marsha Freeman

World government is the winner in the Kyoto global warming treaty negotiations, where no one told the truth about climate change: that the world is moving into a new ice age.

When action concerning scientific questions is based on pragmatism rather than truth, only ill can come of it. Such was the outcome of the 10 days of chaotic negotiations held in Kyoto, Japan, Dec. 1-10, to amend the global climate treaty, signed by 150 nations at the 1992 Earth Summit in Brazil. The purpose of the Kyoto Protocol is to make mandatory the emissions reductions that the 1992 Rio treaty had made only voluntary.

The United States went into the negotiations at Kyoto sporting a middle-of-the-road position, that went along with the hoax that says that increasing carbon dioxide in the atmosphere, primarily from man-made sources, would lead to global warming, with untold catastrophic consequences.

As *21st Century's* new special report, "The Coming Ice Age" documents (see ad on inside back cover), there is no evidence that the atmosphere is warming, and, in any case, man-made carbon emissions are insignificant in the chemical make-up of so-called "greenhouse gases" in the atmosphere. As far as forecasting long-term climate is concerned, Earthlings should be preparing for the next ice age.

While publicly going along whole hog with the hogwash of global warming, President Clinton was not about to go along with binding international regimes that would dictate that the United States government enforce cutbacks in carbon-dioxide-producing economic activity, such as electricity generation, automobile use, and industrial production. So he tried to convince the leaders of other nations that reductions in the emissions of so-called greenhouse gases by the United States could be achieved by "market forces," making use of "energy efficient" technology.

This approach was tried by the Carter Administration in the late 1970s. Despite economic incentives, billions of dollars spent on R&D for energy-efficient "technologies," and public warnings about impending shortages of energy, most Americans recognized this plan as simply a way of cutting their standard of living, and ignored the entreaties. The real aim of the global warming promoters—cutbacks in economic growth—has also been recognized by developing countries, which have no intention of cutting back their emission of industrial gases, thus slowing or eliminating growth in their economies.

For their part, the environmentalists, who say they are appealing to people's concern for the future of the planet, know that draconian austerity measures would be necessary to cut global emissions in half, as they are demanding, and that the only way to do that is by instituting an international regime with the power to penalize.

At Kyoto, the developing countries refused to commit themselves to participate in this process of self-immolation, even at a future time. The leadership of the U.S. Senate has made clear that that body will not ratify the agreement that has been negotiated. The specifics of how this would all work, including enforcement, could not be agreed upon by the 160 countries at Kyoto at all, and has been put off until at least November 1998.

However, it would be a mistake to think that nothing came out of the negotiations. Any nation that signs the agreement, when it becomes available for signature in March, is legitimizing the United Nations as having the authority to enforce international agreements that usurp the power of the government of any individual nation to take responsibility for the welfare of its people.

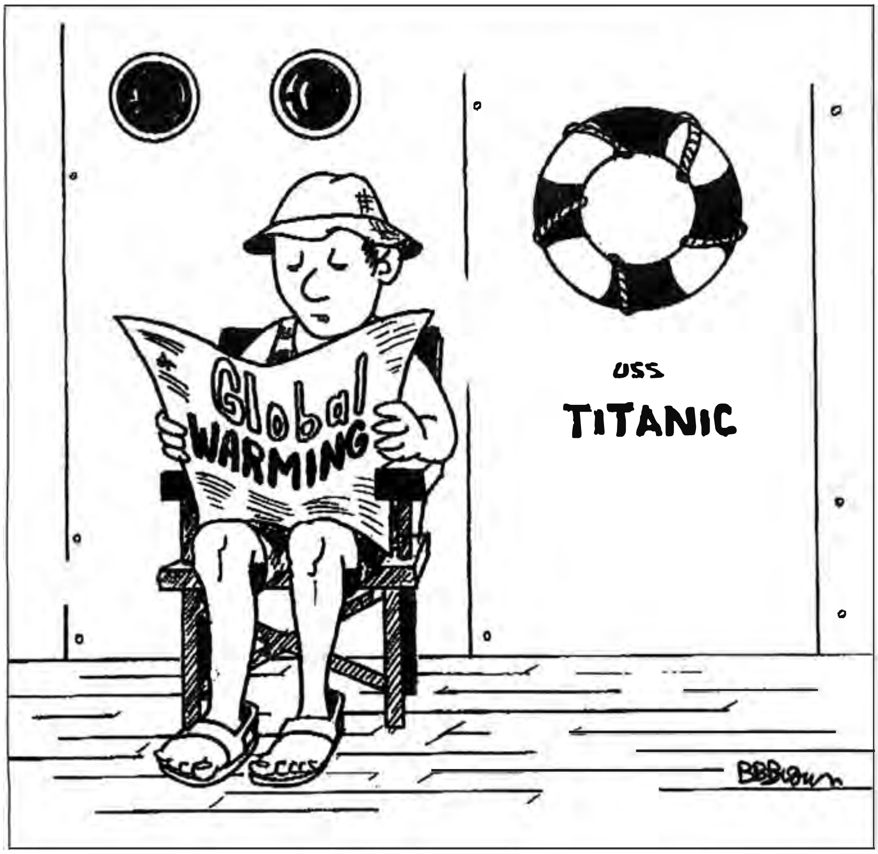
The fact that this could be carried out in the name of what is a scientific hoax, makes it all the more important to defeat the Kyoto Protocol.

Negotiation Through Exhaustion

The U.S. proposal for the Kyoto conference was to reduce emissions to the level of 1990, by the year 2012. The European Union (E.U.), led by Great Britain, demanded that reductions be 15 percent *below* 1990 levels. For Europe, which has already lowered emissions below 1990 levels (through the collapse of industry in Western Germany, as well as through the investment in nuclear technology in Britain and France), this was not a sacrifice. For the United States, such an additional 15 percent cut, would have substantial impact. Japan took an initial position in between, of 5 percent below 1990 levels.

For the first week of the negotiations, the differences seemed to be intractable. Then, on Dec. 8, Vice President Al Gore arrived in Kyoto and told the U.S. negotiating team to be "more flexible." As a result, and after 48 hours of virtually nonstop negotiating the last two days, a "compromise" was reached, whereby the United States will reduce emissions to 7 percent below 1990 levels, the E.U., 8 percent, and Japan, 6 percent. This could mean a cut of up to 30 percent in emissions that the United States would otherwise have produced, by 2012.

According to representatives from the industries that would have to make cuts, especially in carbon emissions, such as coal-fired electric utilities, punitive measures, including hefty taxes on energy to reduce use, would be required to lower



national emissions, because industry could not make large reductions by introducing new technology in such a short period of time.

The E.U. proposed to stick by the 1992 treaty, and exempt the developing nations from any mandated requirements at Kyoto. The U.S. delegation, under threat from a Senate resolution passed in July, that said that the Senate would not ratify any agreement that did not have "new specific scheduled commitments to limit or reduce greenhouse gas emissions for Developing Country Parties," picked a fight with the 130 developing nations at Kyoto to try to get them to participate—and lost.

Here, negotiations through exhaustion did not work. Despite 10 days of pressure, the Chinese delegation refused to be bullied into going along with what it clearly recognized as a threat to China's sovereignty. As the largest and economically fastest-growing developing nation, China took the point for the other 130 developing nations, threatening to walk out of the talks if a proposal were considered that developing countries sign on to a Kyoto Protocol.

So, from the standpoint of the United States, no agreement was reached that will pass muster in the U.S. Senate. The President can try to enact through regulation, budgetary submissions, and legislation, some aspects of the Kyoto Protocol, but he would be doing that with little political support, on an issue the validity of which an increasing number of Americans are questioning.

The Capitulation to Consensus

The most damning aspect of this terrible Kyoto Protocol is that people and nations that knew better, refused to take a truthful stand on the science regarding climate change.

Groups like industry's Global Climate Coalition, and Republican representatives from both the House and Senate, who had made public statements attacking scientific hoaxes before Kyoto, or who even held hearings on Capitol Hill to debunk the fraud of climate modelling and prediction, retreated into positions they thought would pragmatically derail reaching any agreement.

The scapegoat was the Third World, and particularly China, which is projected to become the largest "greenhouse gas emitter" within the next 50 years. The Global Climate Coalition, which from one side of its mouth had said there was no such thing as "global warming," also told elected officials and the American public, through a media advertising campaign, that were there to be a climate treaty, it had to be fair! Fairness, the coalition said, meant that the developing countries should have to make sacrifices, too. Otherwise, corporations would flee the United States to places where they did not have to abide by expensive emissions controls.

For their part, the developing countries also approached the Kyoto negotiations strictly from the standpoint of narrow self-interest, not questioning, not publicly at least, the very basis on which the conference was being held.

And the environmentalists, who had said before Kyoto that this meeting must produce the ultimate agreement, stated, after it was over, that this compromise-ridden mish-mash was a critical "first step," on the "long road" to stopping global warming.

What was not mentioned by the environmentalists, nor by the Chinese either, at least publicly, is that China is pursuing an energy policy based on the expansion of the only two practical methods for generating electricity without producing waste from combustion, which are hydroelectric power stations, such as the Three Gorges Dam, and nuclear power plants. Both are opposed by the environmentalists.

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Reclaiming Your Brains From the Greenwashers

by Marjorie Mazel Hecht

Conservative Environmentalism: Reassessing the Means, Redefining the Ends
James R. Dunn and John E. Kinney
Westport, Conn.: Quorum Books, 1996
Hardcover, 296 pages, $59.95

This is a shocking book, not only for those whose brains have been turned into green spaghetti from years of forced feeding on popular culture, but also for those who have consumed only more moderate helpings of today's environmental mush. What the authors show, using comprehensive historical data, is that industrial development has improved the environment in every respect, and that Americans, especially, have been systematically miseducated on environmental issues. One of the chief discussion points of the book is that "virtually every human activity we see as needed to improve the environment is opposed or not acknowledged" by the environmentalists.

For schools concerned about "balance" in their libraries, this book is a must, for it not only counters the green pabulum, but educates, giving students and teachers both a wealth of reference material for further study and a method of analyzing environmentalist facts, or factoids, as the late Dixy Lee Ray termed the building blocks of green ideology.

The authors review the substantive issues of environmentalism, each in a chapter: agriculture and soil; forests, trees, and floral diversity; wildlife; water and water-related resources; and sanitation and disease. They present an overview, complete with tables and graphs, of the situation as it exists now, in the United States and other industrialized nations, as well as in the developing sector, and they trace the history of each category. So, for example, in the chapter on agriculture, one learns that in America "from 1910 to 1992, the amount of food produced per acre increased 5.59 times faster than the population growth rate," and that technology continues to improve agricultural productivity.

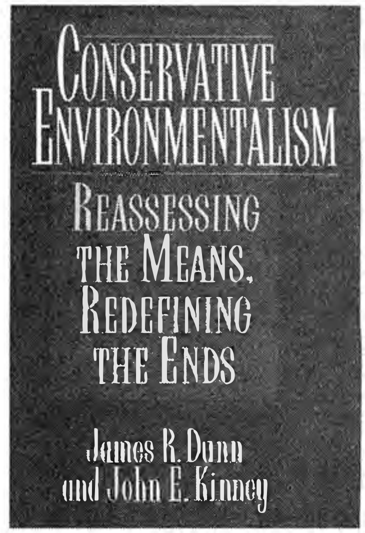
In the Third World, however, agricultural efficiency is stalled where America's was in the 1800s—and is going backward.

The authors develop a useful categorization of environmental conditions, annual per capita gross national product (APCGNP): For Third World nations, this is less than $1,000, and is at the human survival stage. Birthrates are high, lives are short, natural resources are consumed at a high rate, and the environment is deteriorating. Second World nations have an APCGNP from $1,000 to $3,000, and are in a transition stage, with increasing urbanization, and natural resources beginning a process of rejuvenation. For the First World, where the APCGNP is above $3,000, natural resources are actually multiplying—a concept that will shock those who have been brought up on the green mantra.

The authors summarize: "We know of no reasonable alternatives to continuing the technologic changes that have been so successful in improving the environments of industrialized nations. Further, the only successful model for resource multiplication is industrialization and its associated technologies. . . . Going back to the land would also be environmentally disastrous. It is the opposite, getting *off* the land, that leads to a better environment."

Green-Tinted Glasses

One particularly interesting section of the book compares the way the EPA, the average American, and a Third World person look at environmental problems. As the authors elaborate, the Third Worlder has "megaproblems when it



comes to the environment, and these are mostly related to life and death and the availability of the next meal or next drink of water."

America's perceived environmental problems, in contrast, "although often speculative or controversial, are routinely described as 'catastrophic' or 'devastating.' There appear to be no words remaining in our vocabulary to describe problems of the [Third World] type, which may be from a hundred to a million times more severe in human terms."

From here, the authors point out that the wealth America is spending on its perceived environmental problems (what they call "media problems"), and the increasing regulatory micro-management, won't actually save lives, or improve the environment, and certainly won't improve the devastating, and rapidly deteriorating, conditions of life in the Third World. At the same time, as they document, the Third Worlders look (correctly) at industrialization as the answer to their life and death problems. The Third World list of environmental problems today, the authors note, could have been America's list for the 19th century.

Smashing 'Sustainability'

Happily, the authors take on the fraud of sustainability, that piece of conceptual claptrap invented by the United Nations envirocrats to politely tell the industrialized world that it has to cut its consumption, change its lifestyle, eliminate half its family members, and go back to the simple life. This particularly offensive ideological concept has been taken up whole hog by the cowardly industrial groups—including, prominently, the nuclear industry—that think they must accommodate to popular culture, no matter how stupid that culture has become, in order to be "credible" to the public.

The authors argue that in the past 70 years, especially, industrial society has been able to improve production in agriculture and to multiply resources, and, in fact, create new resources, beyond the limit of sustainability.

There are some criticisms I have of the book: It's chief flaw, like that of many of the anti-environmentalist books, lies in its political characterization of the enemy as the "leftist" environmentalists and their "liability culture," which seeks to destroy Western culture and democracy. Although many of the authors' characterizations about this are accurate enough, they fail to state that the genesis of this ideology in the European oligarchy and royal families that created and still direct, top down, the environmentalist groups.

I suspect that this failure comes from their desire to make the book more "credible" to a wider audience, but it prevents the reader from understanding the full picture: Namely, *why* there are people and movements that want to destroy most of the world's population, destroy cultural and scientific optimism, and keep the survivors living in feudal enclaves.

Another criticism is directed at the publisher. This is a book that should be in schools and libraries, and generally widely read, so why not put it out in paperback at an affordable price?

IN MEMORIAM

John E. Kinney

John E. ("Jack") Kinney, a co-author of the book reviewed here, died of leukemia Oct. 6, at age 79. Jack was a good friend of *21st Century,* and a long-time fighter for truth in science and technology issues. "There are not two sides to truth," he once wrote, in one of his many published articles on environment.

Jack did not simply talk or write about critical issues; he did something about them. He was passionately pro-people, and he tirelessly combatted the Malthusians, including those within the Catholic Church and other religious groups.

A Registered Professional Environmental Engineering Consultant, and a Diplomate of the American Academy of Environmental Engineers, Jack was a consultant on environmental issues for government, industry, and civic organizations. He served for 16 years as an adviser to the U.S. Geological Survey and for 17 years as a member of the U.S. Chamber of Commerce committees on Environment and Natural Resources.

Jack spent much time in Africa, in particular, in Uganda, working with governments and communities on development policies, promoting the establishment of a national data base, and stocking libraries. When he came up against the opposition of the international aid agencies, he stuck to what he thought was right, even at the cost of loss of funding for his projects.

Jack's knowledge was wide, and his heart large. We did not always agree, but his integrity was unimpeachable, and his sense of humor unfailing. He was a golden soul, who will be greatly missed.

—*Marjorie Mazel Hecht*

BOOKS RECEIVED

Volcanoes—Crucibles of Change, by Richard V. Fisher, Grant Heiken, and Jeffrey B. Hulen. Princeton: Princeton University Press, 1997. Cloth, 317 pages, $35.

Earth From Above—Using Color-coded Satellite Images to Examine the Global Environment, by Claire L. Parkinson. Sausalito, Ca.: University Science Books, 1997. Paperback, 175 pages, $24. For the general reader.

Airborne Laser—Bullets of Light, by Robert W. Duffner. Foreword by Hans Mark. New York: Plenum Press, 1997. Hardcover, 398 pages, $34.95.

Sources of Hyperbolic Geometry, by John Stillwell. Providence, R.I.: American Mathematical Society, 1996. Hardcover, 153 pages. Papers by Beltrami, Klein, and Poincaré.

Worlds Unnumbered—The Search for Extrasolar Planets, by Donald Goldsmith. Sausalito, Ca.: University Science Books, 1997. Cloth, 237 pages, $28.50.

Dreams, Stars, and Electrons—Selected Writings of Lyman Spitzer, Jr. Princeton: Princeton University Press, 1997. Paperback, 536 pages.

Before the Beginning—Our Universe and Others, by Martin Rees. Reading, Mass.: Addison-Wesley, 1997. Half-cloth, 291 pages, $25. By the Astronomer Royal.

The Infamous Boundary—Seven Decades of Heresy in Quantum Physics, by David Wick. New York: Springer-Verlag, 1996. Paperback, 310 pages, $19.

21st-Century Miracle Medicine—Robo-Surgery, Wonder Cures, and the Quest for Immortality, by Alexandra Wyke. New York: Plenum Press, 1997. Hardcover, 352 pages, $26.95.

Unraveling DNA—The Most Important Molecule of Life, by Maxim D. Frank-Kamenetskii. Revised, updated edition. Reading, Mass.: Addison-Wesley, 1997. Paperback, 214 pages, $15.

Traces of the Past—Unraveling the Secrets of Archaeology through Chemistry, by Joseph B. Lambert. Reading, Mass.: Addison-Wesley, 1997. Half-cloth, 319 pages, $30.

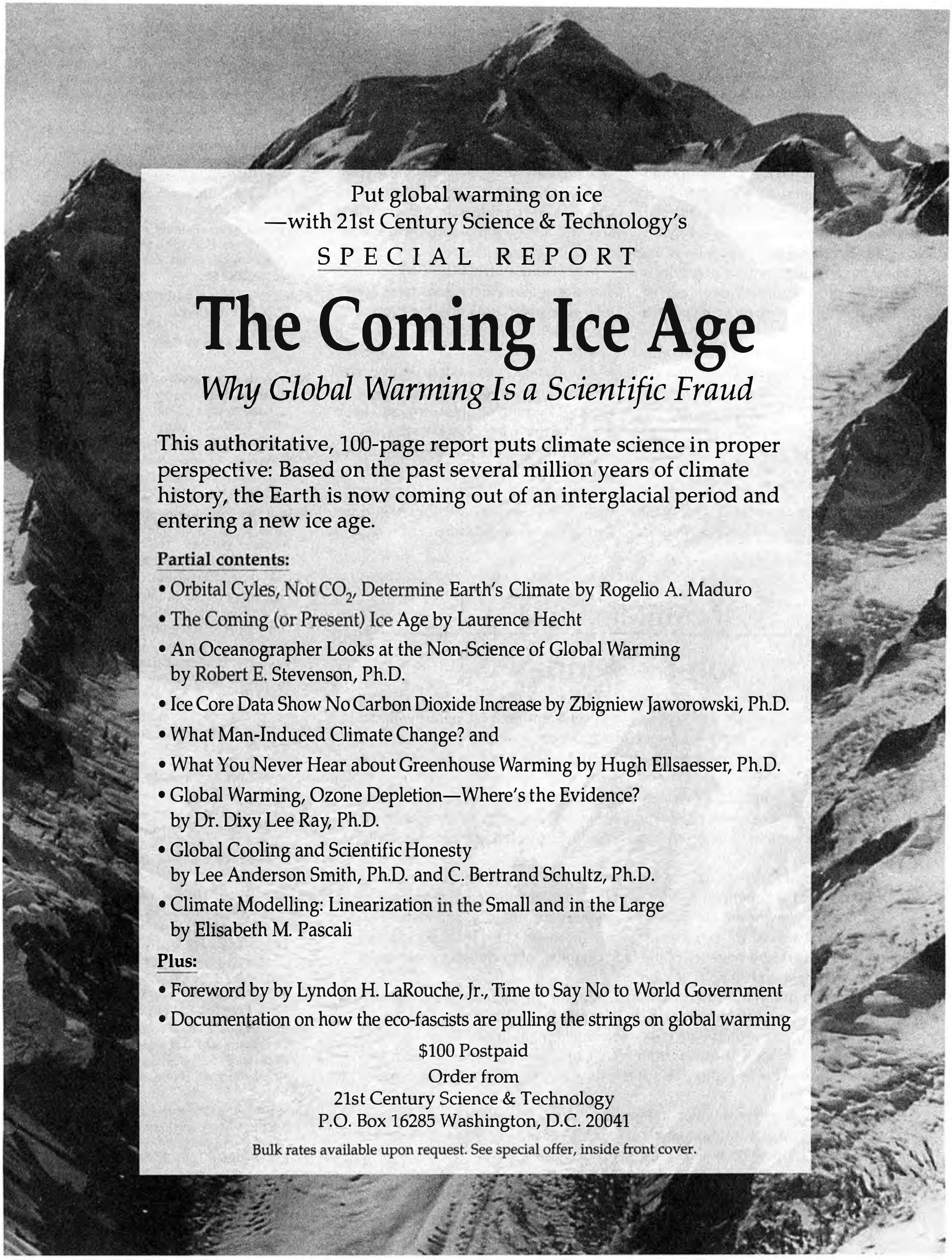
Huxley—From Devil's Disciple to Evolution's High Priest, by Adrian Desmond. Reading, Mass.: Addison-Wesley, 1997. Half-cloth, 820 pages, $37.50.

Hot Talk Cold Science: Global Warming's Unfinished Debate, by S. Fred Singer. Oakland, Calif.: The Independent Institute, 1997. Paperback, 120 pages, $14.95.

Rain of Iron and Ice—The Very Real Threat of Comet and Asteroid Bombardment, by John S. Lewis. Reading, Mass.: Addison-Wesley, 1997. Paperback, 240 pages, $13.

The Fire Within the Eye—A Historical Essay on the Nature and Meaning of Light, by David Park. Princeton: Princeton University Press, 1997. Cloth, 377 pages, $29.95.

A Logical Journey—From Gödel to Philosophy, by Hao Wang. Boston: MIT Press, 1997. Hardcover, 391 pages, $40.


Put global warming on ice
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The Coming Ice Age
Why Global Warming Is a Scientific Fraud
This authoritative, 100-page report puts climate science in proper perspective: Based on the past several million years of climate history, the Earth is now coming out of an interglacial period and entering a new ice age.
Partial contents:
• Orbital Cyles, Not CO2, Determine Earth's Climate by Rogelio A. Maduro
• The Coming (or Present) Ice Age by Laurence Hecht
• An Oceanographer Looks at the Non-Science of Global Warming by Robert E. Stevenson, Ph.D.
• Ice Core Data Show No Carbon Dioxide Increase by Zbigniew Jaworowski, Ph.D.
• What Man-Induced Climate Change? and
• What You Never Hear about Greenhouse Warming by Hugh Ellsaesser, Ph.D.
• Global Warming, Ozone Depletion—Where's the Evidence? by Dr. Dixy Lee Ray, Ph.D.
• Global Cooling and Scientific Honesty by Lee Anderson Smith, Ph.D. and C. Bertrand Schultz, Ph.D.
• Climate Modelling: Linearization in the Small and in the Large by Elisabeth M. Pascali
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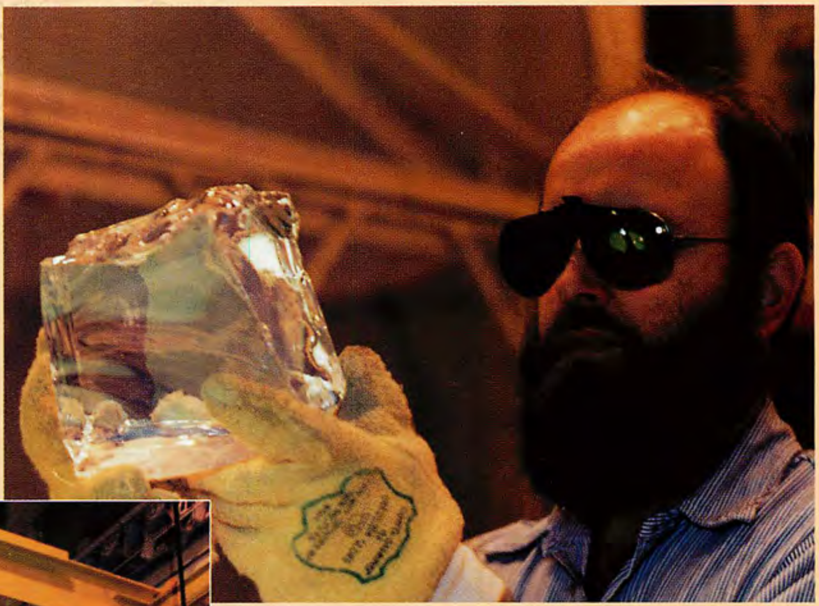
MAKING TELESCOPE MIRRORS FOR THE 21ST CENTURY

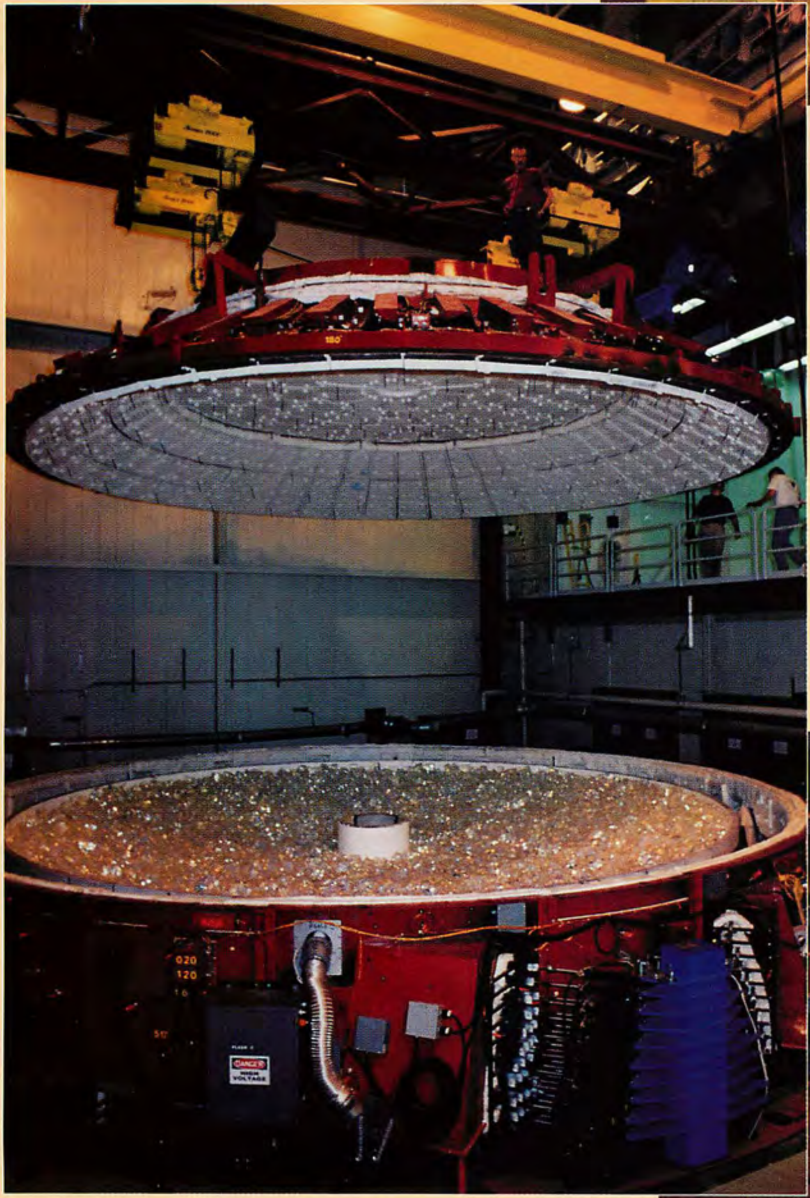
This issue celebrates the successful casting of the first 8.4-meter mirror for the Large Binocular Telescope, which is being built on Mt. Graham in Arizona. On Sept. 11, the rotating oven at the University of Arizona was opened, and the casting declared a success. The 8.4-meter mirror is the largest monolith mirror in the world, and the largest embodiment of the revolutionary new principles for telescope mirrors developed at the university's Steward Observatory Mirror Laboratory.

David Cherry's firsthand account (page 70), along with interviews with astronomers Roger Angel and John Hill, reports on these principles and their significance.

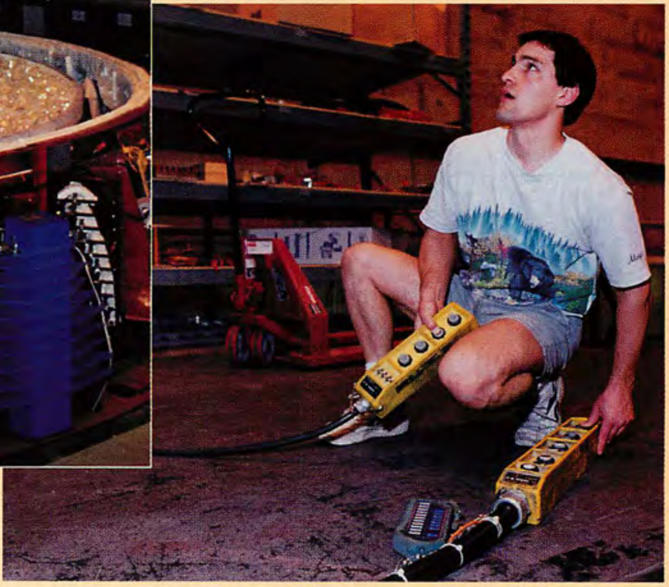


Photos by John Florence, University of Arizona

Technician Dan Watson (above) inspects a chunk of glass for the Large Binocular Telescope's first mirror, through polarized lenses. Chunks with inclusions such as dust specks were rejected.



◀ Technician Phil Muir stood atop the furnace dome, Jan. 3, 1997, as it was lowered by Randy Lutz (below). The glass chunks—21 tons in all—can be seen in the mold. The furnace, mounted on a turntable, spins to produce a steep paraboloidal surface on the molten glass.

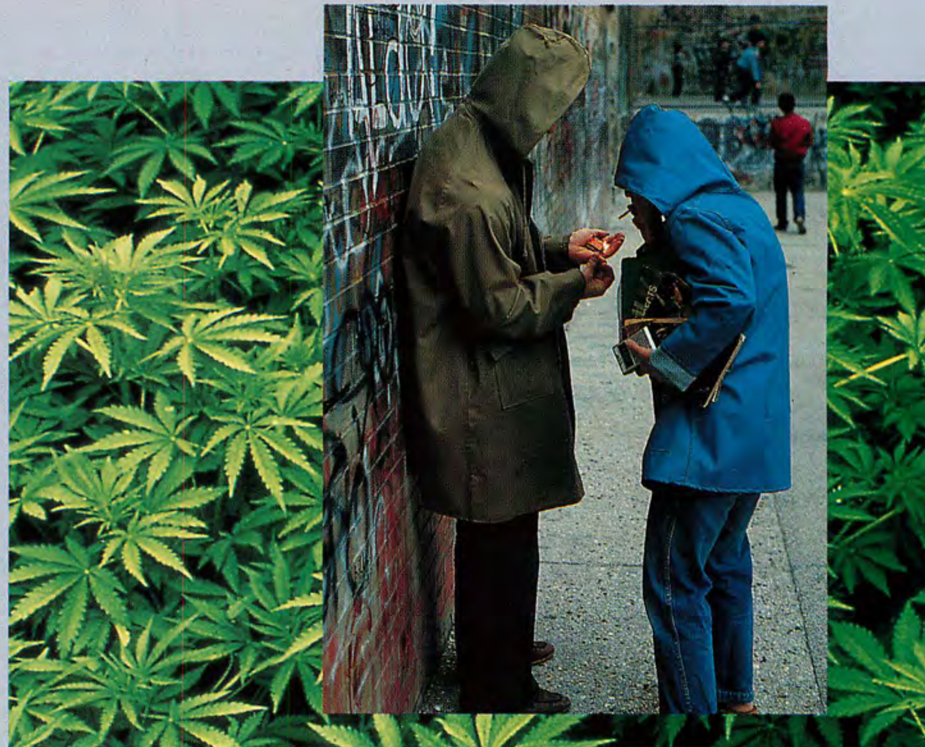


Technicians Watson, Muir, and Lutz were three of seven oven pilots, monitoring and controlling the furnace in shifts around the clock, during the months of cooling and annealing.

In This Issue:

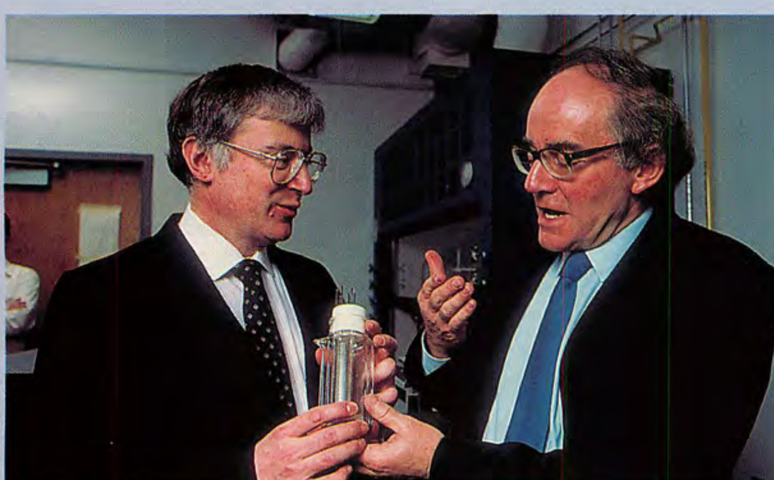
HOW MARIJUANA SOFTENS BRAINS

Don't believe the propaganda from the marijuana legalizers that pot is a "soft" drug: The latest scientific research confirms that marijuana damages human cognitive faculties, and that the damage increases with higher doses and more frequent use. Further, as Karen Steinherz and Thomas Vissing report (page 59), the marijuana legalizers are continuing the tradition of the 19th century British colonialists, who pushed hashish to keep the coolies happy while they worked, and of their 20th century New Age successors, who designed the Brave New World.



Philip Ulanowsky

Brave New World? More than 5.5 million Americans smoke marijuana weekly, and it is the most frequent drug used by teenagers.



University of Utah

COLD FUSION AFTER 8 YEARS

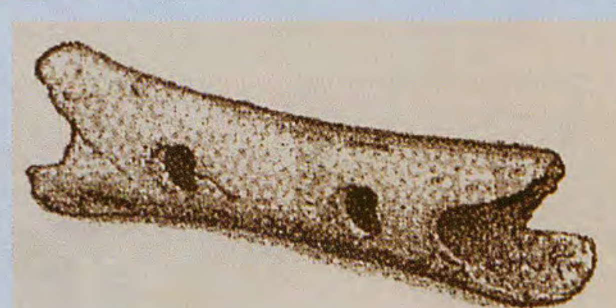
Nuclear scientist Edmund Storms reviews the status of cold fusion research (page 19), including the recent evidence for transmutation. Chemically assisted nuclear reactions is a better name for the effects that are being observed, he says. Storms, who retired from Los Alamos National Laboratory after 32 years, takes on the anti-science of the cold fusion skeptics, reviews the proposed theoretical models, and provides numerous technical references for further reading.

Two otherwise conventional scientists, Profs. Stanley Pons (left) and Martin Fleischmann, proposed in 1989 that nuclear reactions could be initiated in palladium containing a high concentration of deuterium.

A NEANDERTHAL FLUTE IN CLASSICAL TUNE

Finding a fragment of a diatonic flute that is 43,400 to 67,000 years old, has jolted those ethno-musicologists and anthropologists who do not accept the existence of a universal human culture. David Shavin describes the Neanderthal flute, and the evidence compiled by musicologist Bob Fink that it is based on the diatonic musical scale, normally associated with the classical art of Bach and Mozart (page 6).

The 43,400- to 67,000-year-old bone flute segment, with four holes, two complete and two partial (at each broken end of the bone).



Bob Fink