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Voyages of Discovery

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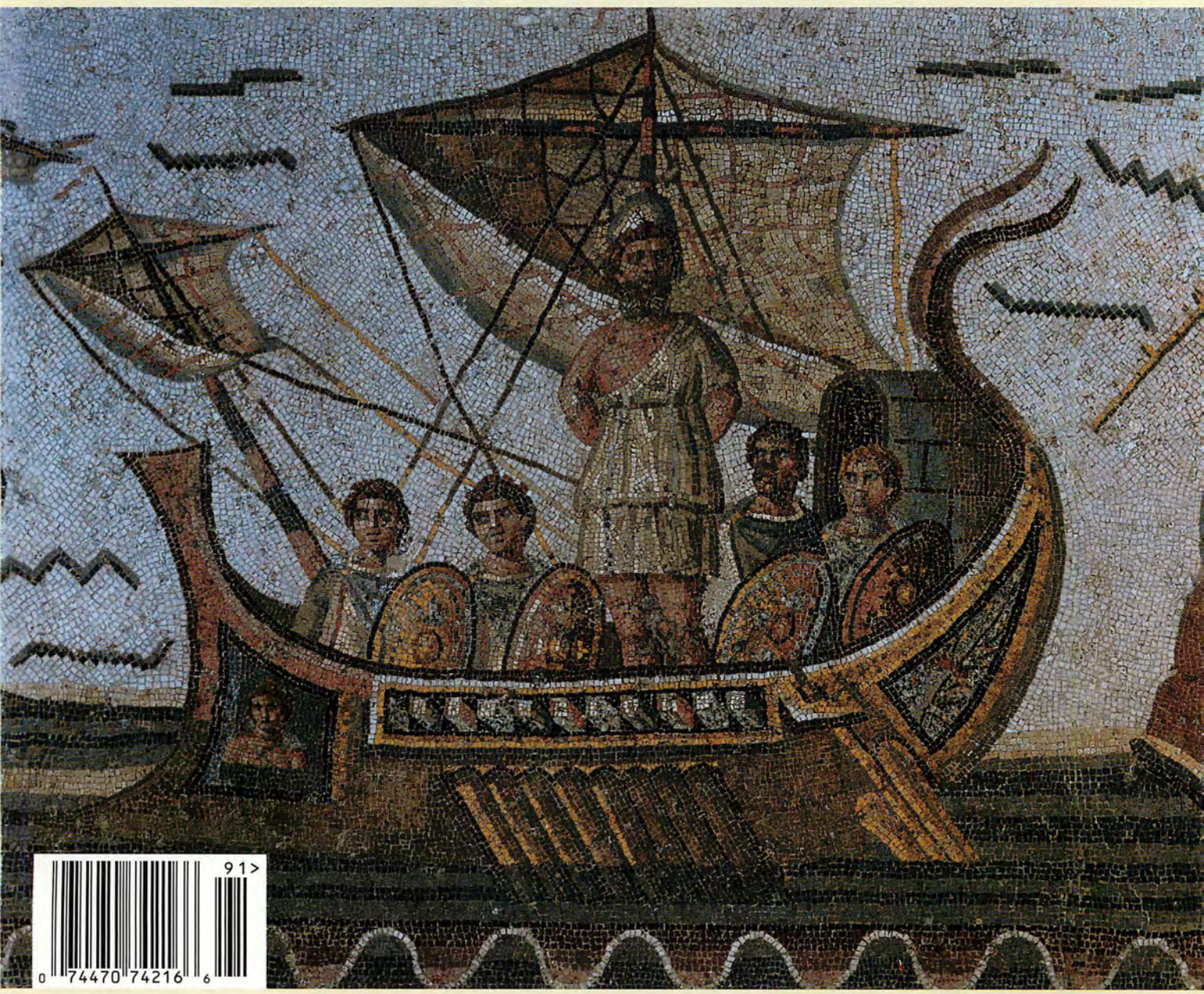

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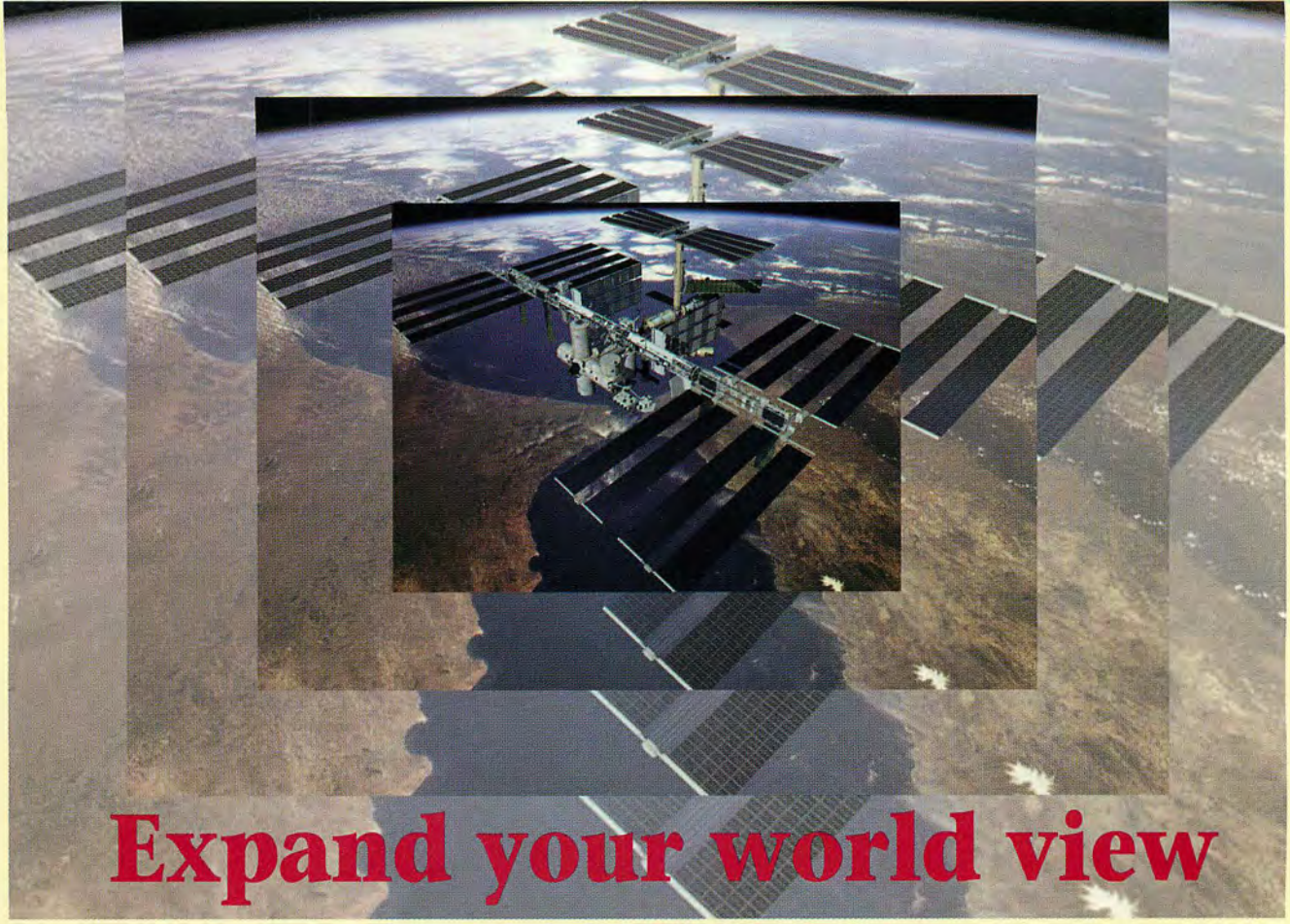

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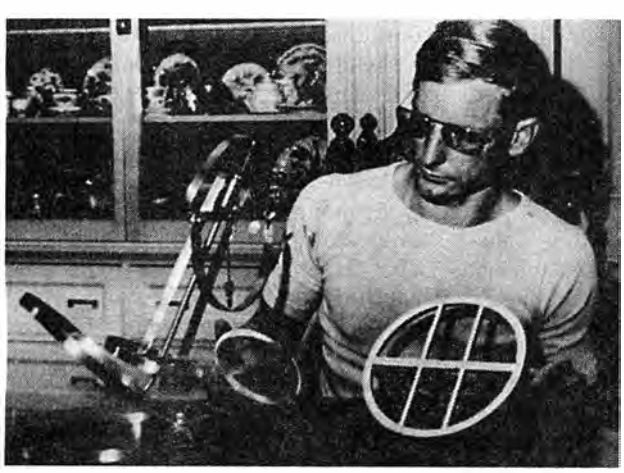
Features



© Barry Fell, *America B.C.*, (New York: Simon & Schuster, 1976)

Dr. Sentiel Rommel with his reconstruction of Maui's tanawa, the 3rd century B.C. astronomical instrument, based on the cave drawings of Maui. The friend of Eratosthenes, Maui was astronomer and navigator for the Egyptian flotilla that set out to circumnavigate the globe during the reign of Ptolemy III. *See p. 75.*

News

Departments

On the cover: Roman mosaic of Odysseus and the Sirens, 3rd century, from the National Museum du Bardo in Tunis, Tunisia. Photograph by Erich Lessing/Art Resource N.Y. Cover design by Rosemary Moak.

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The Mind of the Discoverer

In this issue, the ground-breaking article on the principle of discovery by economist Lyndon H. LaRouche, Jr., a member of *21st Century's* scientific advisory board (p. 24), and the companion article on Homer's *Odyssey* by Gabrielle Liebig (p. 36), combine information from ancient sources with modern archeological findings, including those of the late Barry Fell of Harvard University, to shed much new light on the prehistory of mankind.

There were prehistoric maritime civilizations which regularly plied the entire width of the Atlantic, Pacific, and Indian Oceans. Later river-based cultures were the result of cultural decline from these earlier maritime civilizations. Through mostly indirect, but reliable evidence, we know a great deal about these ancestors of ours, of the prehistoric maritime civilizations.

This kind of new knowledge should be a source of excitement and happiness. Instead, for many readers, these articles will be extremely disquieting. Why? Because of certain prejudices, or preconceived notions. These include the belief that the first human being was born no earlier than 20,000 to 25,000 years ago; that civilization began suddenly in Mesopotamia at some time after about 4,000 B.C., as an oligarchical slave society, and spread elsewhere from there; and that it was impossible to reliably cross the Atlantic or Pacific Oceans before some time in the Christian Era.

But the re-examination and re-evaluation of preconceptions and established axioms, especially widely held ones, is always the first question in science. That is why the history of science as such, conscious science, begins with the Classical Greeks, and especially Plato and his Academy: because they were the first in history to understand this. Only after the Italian Renaissance rediscovered this principle from the Greeks, was science made possible once again.

Thus, there can be no scientific archeology or prehistory, unless these received preconceptions are re-examined.

The First Question in Science

Thus, the first question in science is the mind of the discoverer, in this sense. Then, in archeology and prehistory, the mind of the modern discoverer must look into the mind of the prehistoric discoverer, from his knowledge of the discovery itself.

Take language, man's first discovery. Look at the highly developed languages which were required to communicate the advanced astronomy and other mental requirements of the prehistoric maritime civilizations. Take the highly developed, pre-literate Indo-European language, for example. When we find that the most advanced features of Sanskrit, map onto the same features of Classical Greek, we know that the preliterate ancestor of both, also shared those features, and probably more. In many respects it was in advance of any language used today.

Embedded in that language, was the extended development of layered axioms, discovered by many discoverers, in lawful succession—presumably poets or scientists, or both, as Eratosthenes was both later.

History itself is in essence nothing but the layered discovery of new principles by the human mind—or, alternately, the failure to discover the new principle when it is needed. Given this understanding, the preconceptions listed above, and others like them, are no more tenable than Bishop Usher's earlier dogma, also forced down the throat of archeology in its time, that the world was created in 4004 B.C.

—Antony Papert

Letters

An Antarctic Route From Egypt to America

To the Editor:

If, as you indicate, Rata and Maui had access to Egyptian navigation knowledge dating back at least 2,600 years [see "The Decipherment and Discovery of a Voyage to America in 232 B.C.," *21st Century*, Winter 1998-1999, p. 62], and if that knowledge included navigation as far as the southern polar circle, then the route on the accompanying map might be one of the ones of choice—a path-of-least-resistance route.

They would have known of the southerly current along the eastern side of Africa, and known that at about 45° latitude south, it turns eastward, driven by the Indian Ocean eddy, southern leg. Then past Australia and New Zealand and into the southern leg of the South Pacific gyre (eddy) where the eastward current would continue onto South America, with Antarctica on the right. En route here, Pitcairn Island would have been encountered.

Then, up the coast of South America, to just below the equator, where the northern leg of the South Pacific wheel (drift) shoots westward. After this, they would encounter the Polynesians. Note that upon arriving at the South American coast, had they gone south, they would have found the Atlantic.

Further westward voyaging would lead to McCluer Bay, and then back to Egypt. But since they did not return, perhaps some remained in Polynesia, and some headed home and met disaster.

All of the above, providing that the La Niña, the prevailing counter clockwise southern Pacific gyre was in effect. During El Niño, the southerly wind that churns cold water from the south, up the South American coast "falls," and all hell breaks loose.

Apparently, whatever forces El Niño, also impacts the Indian Ocean and North Pacific gyres, disrupting the prevailing currents—or maybe not.

The arrows on the map depicting the current flows are from a Replogle World Scholar globe.

Hector S. Cuellar
Houston, Texas

The Real Gore

To the Editor:

Here is a challenge for your readers—a *blind test*, to see if they can distinguish between Al Gore and the ecoterrorist Unabomber. Here are some quotes selected from Al Gore's book, *Earth in the Balance*, and some from the Unabomber's manifestoes, as published in the national press. Can your readers (presumably more literate than most) tell who wrote what?

(1) "Technological hubris tempts us to lose sight of our place in the natural order and believe that we can achieve whatever we want."

(2) ". . . It is certain that technology is creating for human beings a new physical and social environment radically different from the spectrum of environments to which natural selection has adapted the human race. . . ."

(3) "Today, most of the world is looking the other way, pretending not to notice industrial civilization's terrible onslaught against the natural world. . . . Standing bravely against this juggernaut, a new kind of resistance fighter has appeared: men and women who have recognized the brutal nature of the force now grinding away at the forests and oceans, the atmosphere and fresh water, the wind and the rain. . . ."

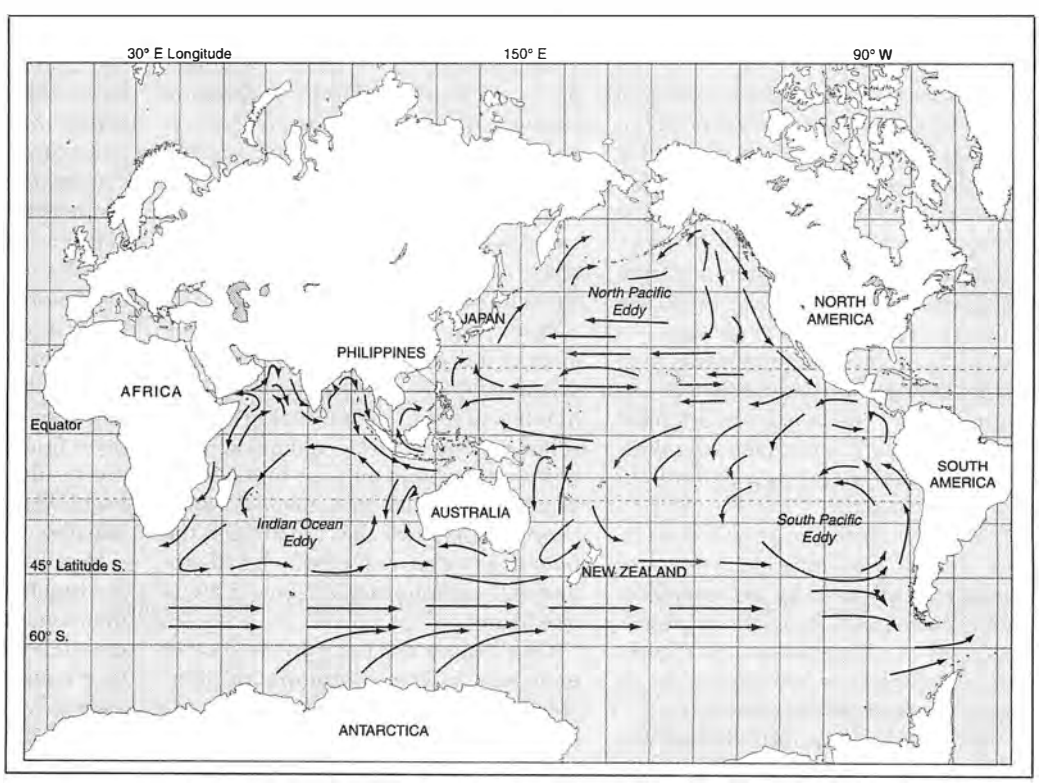
(4) "Just as a drug addict needs increasing doses to produce the same effect, our global appetite for the Earth's abundance grows each year."

(5) "Once a technical innovation has been introduced, people usually become dependent on it, so that they can never again do without it. . . ."

Rick Sanders
Loudoun Heights, Va.

EDITOR'S NOTE

The answers appear on page 13.



The Foibles of Air Pollution Research

by Frank Cornell, D.D.S., M. Sc.

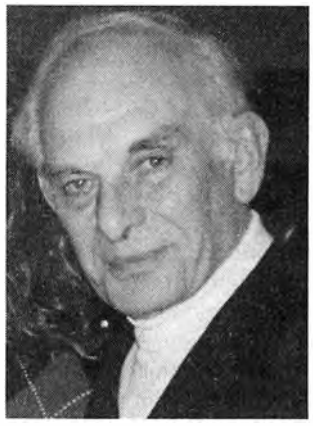
Let me tell you of my own experience in air pollution research. My story dates back to 1969, when the idea of "air pollution" was just getting off the ground. The Graduate School at Fairleigh Dickinson University in New Jersey had a Dental School in Hackensack, but no medical faculty. In order for me to receive a Master's Degree in Physiology, it was necessary for me to do my thesis in the Department of Physiological Chemistry. My mentor was Dr. Louis J. Ramazzotto, who may still be at the school, and he shares the "blame" for what happened.

My thesis was titled, "The Effect on Certain Respiratory Enzymes from Exposure to Common Air Pollutants." The title itself proves nothing except that I was naive. Who could call the substances in question "pollutants" until after they were proved harmful? But then again, whoever could doubt that sulfur dioxide and nitrogen dioxide were harmful?

The procedure I used was taken from something called "The Method of Cooperstine and Lazarow," which, despite the outcome of my own tests, may well still be in use. Briefly, it involved sacrificing either rats or guinea pigs (I used both), and making tissue homogenates from heart, liver, lungs, and kidneys in a saline solution at a controlled temperature. An aliquot of each homogenate was then tested spectrophotometrically for enzyme activity. The result was a typical activity curve which declined over time, at a rate which was almost uniform for all the tissues used.

Tanks of air containing certain percentages of either sulfur dioxide or nitrogen dioxide were available for the next procedure. Another aliquot of the same homogenates was subjected to a short exposure to "polluted" air by bubbling the air through the homogenate under test.

After this, the exposed aliquot was tested for enzyme activity. The results



were uniform, no matter which animal was used, which organ was used, which enzyme was under test, or which "pollutant" was employed. That is to say, enzyme activity declined in the exposed homogenates about twice as rapidly as it did in the unexposed homogenates. Bingo! Easy thesis! Easy Master's Degree!

But that was not the end of the story. I put in another three months repeating every test before I went to my typewriter. I am no genius, but even I could see that "The Method of Cooperstine and Lazarow" has no control. After I had complained about this to Dr. Ramazzotto, he ordered a flask of pure air for me to use in my tests.

Pure air is, of course, a mixture of the three or four primary gases in the atmosphere without any measurable amount of other gases, or "impurities" (such as sulfur dioxide or nitrogen dioxide). The result of bubbling pure air through the tissue homogenates gave tracings which strongly suggested that it had been the *bubbling procedure itself* which had produced the diminished enzyme activity (see figure).

Cooperstine and Lazarow used other enzymes in the prototype of their "Method," but that is not important. My enzymes were cytochrome oxidase and succinic dehydrogenase, which is also not important. In the Krebs and Meyerhof cycles, there are many other enzymes which could be tested for activity under the conditions described.

What is important, is that this "method" is useless for proving anything, except that the act of bubbling a gas, contaminated or not, through a tissue homogenate will accelerate the decay of enzyme activity.

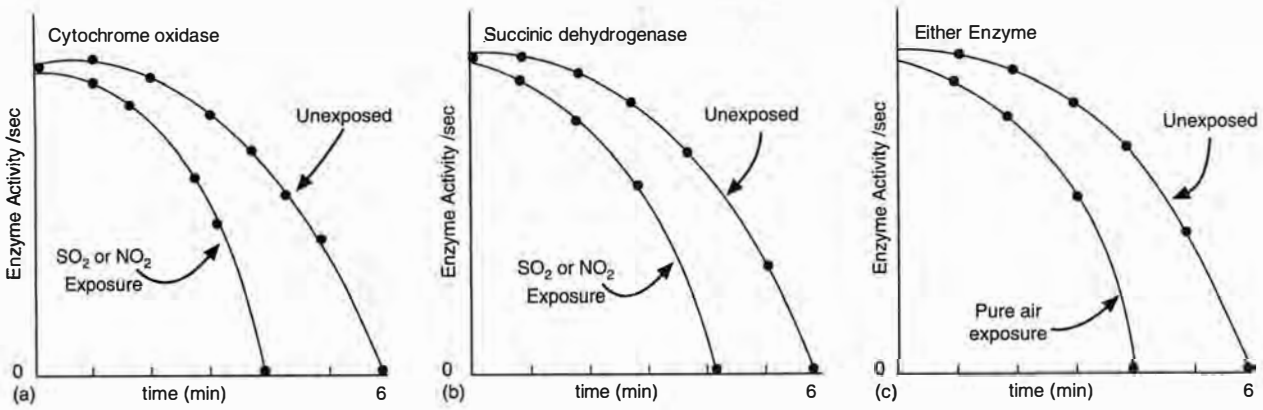
If the Method of Cooperstine and Lazarow was in any way complicit in persuading people to accept the concept of air pollution, that concept itself is a fraud and deserves to be unmasked—which is the second part of this letter.[1]

Censored

By the time I was awarded my degree, I was already in Germany with my family, and enrolled at the University in Düsseldorf, where I wanted to write a doctoral thesis on the physiology of the human voice. After two years, I returned to the United States and paid a visit to Dr. Ramazzotto's department at Fairleigh Dickinson University. My reception was cooler than I had expected.

I was informed that several journals had rejected my master's thesis for publication, as had as several of the more popular science publications. However, the *Colorado Journal of Mines* had published a report which included my name as one of its 14 authors. I was handed a copy of that journal and found that four pages of that particular issue had not been bound into the volume. Perhaps my results were on one of those four pages. Perhaps not. But neither I nor anyone else will ever know.

With that, of course, my interest in the biochemistry of air pollution came to an end. I went ahead, however, with my studies of the human voice, and, after a couple of years I had a pretty good idea of what was going on in that area as well. But that's a whole 'nother story, as they say.



A FLAWED EXPERIMENT

The Method of Cooperstine and Lazarow is useless for proving anything, except that the act of bubbling a gas, contaminated or not, through a tissue homogenate will accelerate the decay of enzyme activity.

Catalytic Converters

The other reason I write is to make some comments about catalytic converters, in addition to pointing out that they are enormously expensive in comparison to the job they do.

Originally, these devices were supposed to rid the atmosphere of the two most "dangerous" pollutants known to man, namely, sulfur dioxide and nitrogen dioxide; and, as everyone knows, these two gases are routine components in the exhaust of automobile engines. Now, take a look at a list of exhaust components:

- carbon monoxide, CO, from incompletely burned fuel
- carbon dioxide, CO_2, from completely burned fuel
- water vapor H_2O
- sulfur oxides SO, SO_2, and so on
- nitrogen oxides NO, N_2O, NO_2, and so on
- various hydrocarbons (H_x-C_y) and so on, cyclics and chains of all kinds.

Basically, gases like these pass from the engine to the catalytic converter in almost all vehicles normally now in use. Everything that goes into a catalytic converter goes out the other end, atom for atom. Nothing "disappears." Nothing remains in the converter. All the converter does is "convert" one substance to another, and it does this by ionizing the various gases that pass through it.

Briefly, when carbon dioxide goes into a converter, it contacts the platinum inside, and is broken up into carbon and oxygen ions. When water is broken up, it forms hydrogen and oxygen ions. The same is true for any other gas entering the catalytic converter. None of the ions formed exit the converter as ions. They can only remain in the ionic form in the presence of the platinum catalyst. As they exit the converter and go out the tailpipe, all the negative ions combine again with whatever positive ion is handy, without rhyme or reason. This is how a free sulfur ion may combine with hydrogen instead of oxygen. And this is how a nitrogen ion may combine with an ion of hydrogen and an ion of carbon.

The same reaction gets rid of some of the sulfur dioxide in the car exhaust by forming hydrogen sulfide, which is a lethal gas. The other reaction gets rid of some of the nitrogen dioxide by forming hydrogen cyanide, a gas so lethal it has been used to execute criminals in several states.

Another problem is that much of what enters a converter passes through it without being "converted" to anything else. This is partly because nothing mankind has ever devised is 100 percent efficient. It is also because no chemical reaction can ever go to "completion." (The probe that some inspector puts up your tailpipe is testimony to this, because he is not measuring whether you are "polluting" the air or not. He is measuring only *how much* you are polluting the air.)

So what motorists are doing in reality, and for the most part, is exchanging their relatively innocuous sulfur dioxide and nitrogen dioxide for two of the most dangerous gases known to man. Everyone is now familiar with the "eggy smell" that their car gives off now and then. That is largely the smell of hydrogen sulfide. Everyone has also smelled a "perfumy smell" from a car's exhaust. That is not only cyanide, but also the smell of anilines, nitriles, and other compounds where hydrocarbons combine with nitrogen.

A final component of automobile pollution might include hydrocarbons, or large molecules of unburned gasoline. A good engine tune-up will reduce these to amounts tolerable even to an environmentalist. At the same time, if sulfur and nitrogen were to be eliminated from the gasoline at the refinery, this would make catalytic converters totally superfluous.

I wonder why no one ever thought of that?

Notes

1. The experiment described here was an attempt to adapt the Method of Cooperstine and Lazarow to prove that nitrogen dioxide and sulfur dioxide are poisonous to some respiratory enzymes. As I was able to show, these substances, mixed with air, are no more deleterious to such enzymes that is pure air itself.

   In fairness to the original researchers, it should be pointed out that they used CN^- ion, a known poison, in their model. The cyanide was not bubbled through the enzyme solutions as a gas. It was added directly to the solutions, killing all enzyme activity almost instantaneously. In comparison, NO_2 and SO_2 are harmless.

   For this reason, the Method of Cooperstine and Lazarow is not adaptable to "prove" the fact of air pollution by NO_2 or SO_2.

Global Cooling Is Under Way

by Jack Sauers

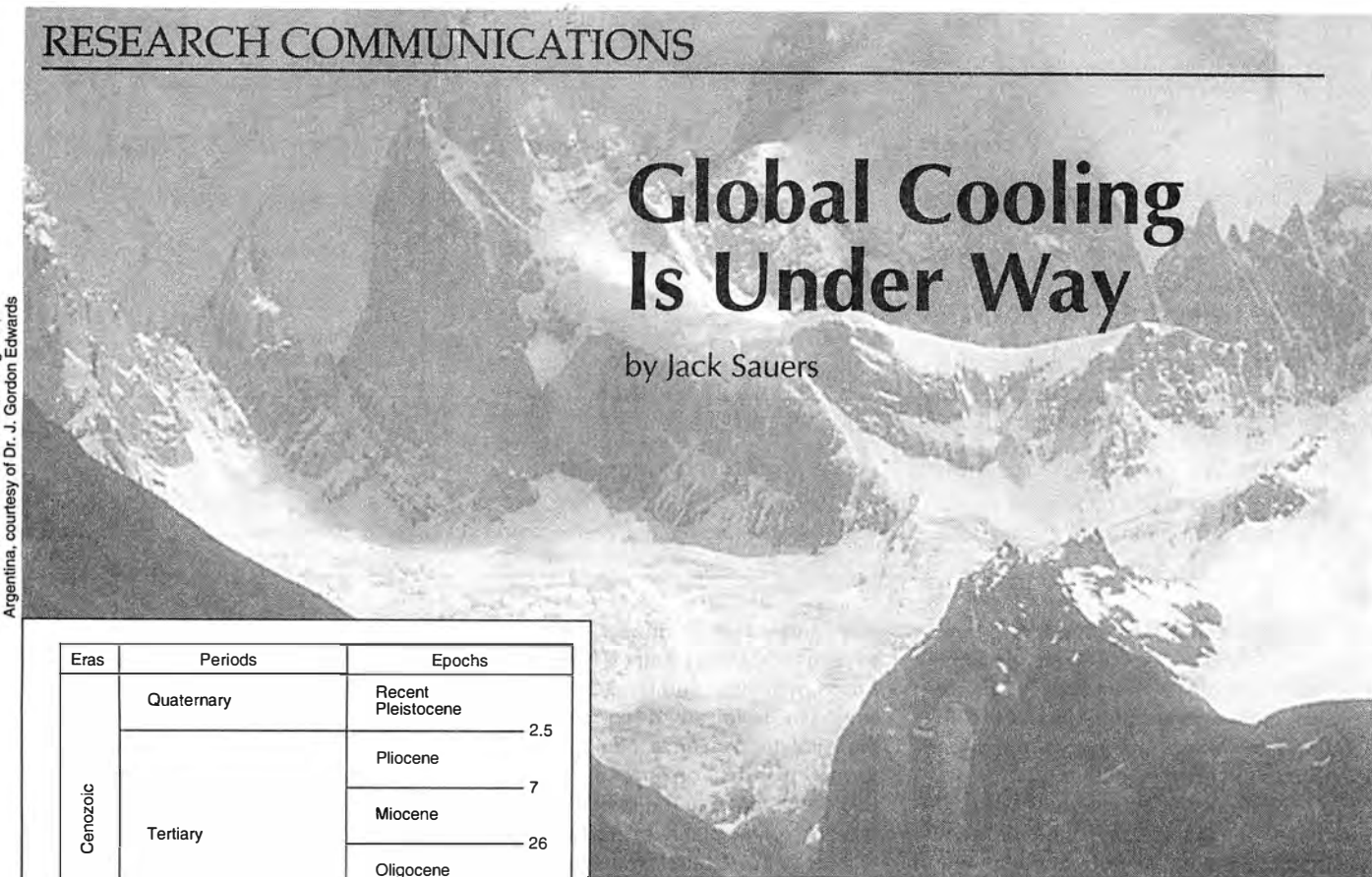


Photo of Glacier National Park, Patagonia, Argentina, courtesy of Dr. J. Gordon Edwards

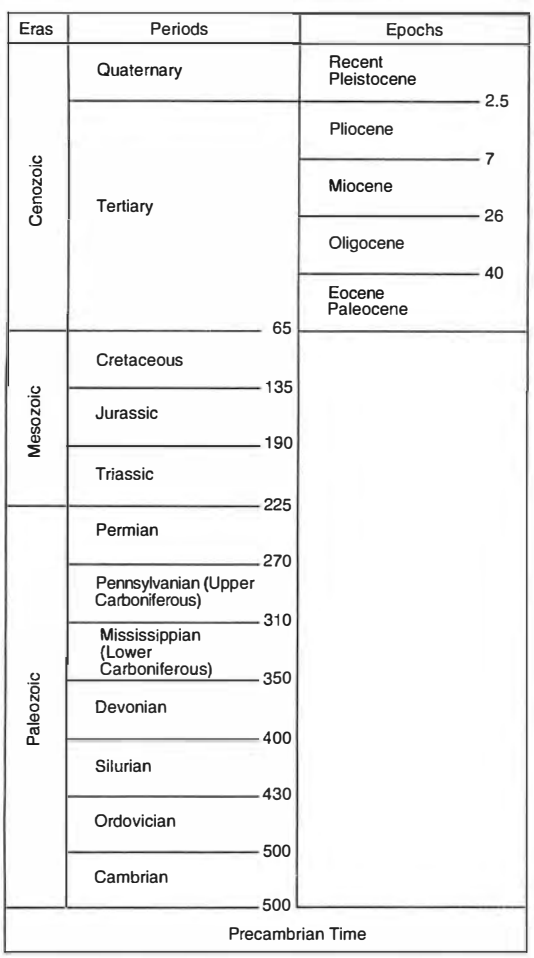


Figure 1
THE GEOLOGIC TIME SCALE
Time units of the geologic time scale. (Numbers are absolute dates in millions of years before present.)

Global cooling has been under way for the past 50 million years, since the deposition of the palm-bearing Eocene (See Figure 1.), or Lower Tertiary Swauk Formation of eastern Washington, from which I have collected nice paleobotanical palm leaves and placed them in the Burke Museum at the University of Washington, in Seattle.

Since the Tertiary, the area which is now eastern Washington has seen repeated glaciations in the Quaternary or Pleistocene, with the deposition of glacial deposits of all types, such as sand, gravels, and glacial till.

Over the past 11,650 years of the Holocene Interglacial (that is, since the last glaciation), temperatures worldwide rose until the Holocene maximum (See Figure 2.) about 6,000 years ago and have been declining ever since—which is common knowledge in extensive geologic literature.

Many palynology (pollen) studies from the northern Puget Sound area to the East Coast, carried out by a large number of researchers studying pollen in ice cores covering the last 3,000 years, have shown a cooling trend in the changing population of trees. For example, western hemlock, which thrives in a colder and wetter climate, has replaced douglas fir in the Northern Puget Sound area, and has replaced other tree types from there to Idaho, to Michigan, south of Lake Superior.

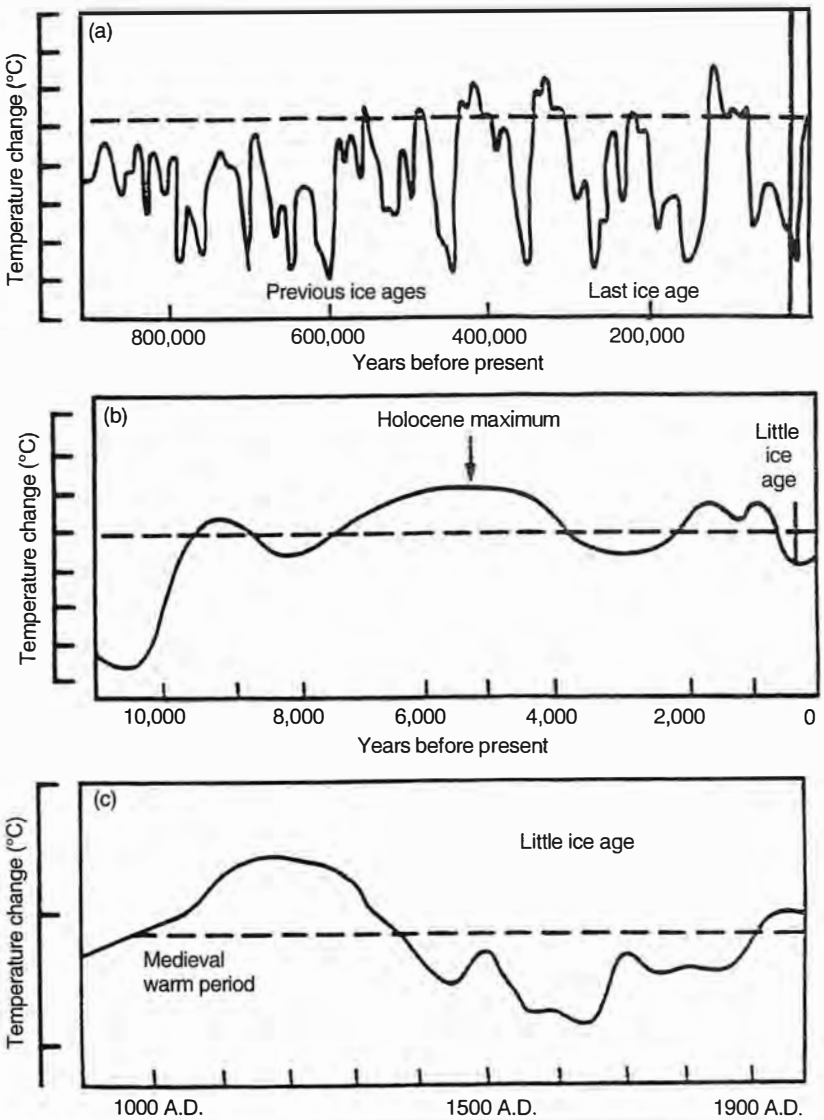
Over the last 650 years, since the Medieval Warm Period, a boreal forest of spruce, colder loving pines, and birch, has replaced the temperate forest of beech, maples, oaks, and white pine in Southern Ontario, as reported by Ian Campbell and John McAndrews, of the Canadian Forest Service, in their paper, "Forest Disequilibrium Caused by Rapid Little Ice Age Cooling."[1] This is similar to the cooling at the end of the Eemian In-

Evidence from pollen core samples shows that species of trees that thrive at lower average temperatures are currently moving farther south, just as happened in the time before the last Ice Age. In the last 650 years, there has also been a lowering of the tree line for douglas fir in the Cascade Mountains in Washington by 1,000 feet.

Figure 2
GLOBAL TEMPERATURE VARIATIONS ON THREE TIME SCALES

These are schematic diagrams of global temperature variations since the Pleistocene on three time-scales: (a) the last million years, (b) the last 10,000 years, and (c) the last 1,000 years. The horizontal dashed line represents conditions near the beginning of the 20th century.

Source: IPCC (Intergovernmental Panel on Climate Change), 1990. *Climate Change: The IPCC Assessment*, Eds. J.T. Houghton, G.J. Jenkins, and J.J. Ephraums (Cambridge: Cambridge University Press) Figure 7.1.



terglacial, 115,000 years ago, where a boreal forest replaced a temperate forest, as described by G. Woillard in "Abrupt End of the Last Interglacial s.s. in North East France."[2]

The last 650 years have also seen a lowering of the douglas firs' tree line by 1,000 feet in the Cascade Mountains of Washington state, as evidenced by the U.S. Forest Service's thousands of test plots. Their test plots in the Olympic Mountains have also showed a slowing of tree growth, which is evidence of a strong increase in global cooling, throughout the 1990s.

We can see a strong global cooling since mid-century, as reported by K.R. Briffa, P.D. Jones, et al. in "Influence of Volcanic Eruptions on Northern Hemisphere Summer Temperature Over the Past 600 Years,"[3] The strongly declining summer temperatures showing global cooling since mid-century, as documented in that paper, seems to correlate with both declining solar output to some degree, rising vulcanism, and rising precipitation at higher latitudes. The Northern Tier U.S. and Scandinavian weather station data, also confirms such a cooling trend.

It should be noted that the same P.D. Jones who co-authored that study, had been publishing studies on "global, or anthropogenic warming," using various fudge-factor linear models.[4] Apparently, these fudge-factor global warming models, do not hold up very well, when compared to real-world observational scientific data trends (such as palynology, tree ring, and temperature observations from good stations), and when compared to

TEMPERATURE PATTERNS IN SPOKANE, WASH. (1890-1997)

Shown are the observed temperature declines of the U.S. Weather Service site in Spokane, Washington. At the current rate, the annual mean temperature will have fallen another 5.7 ° F by 2007. Strong increases in precipitation are also observed. The neo-boreal conditions of a new Little Ice Age or major glaciation can be expected to prevail as a result of this natural trend.

July monthly mean temperature (°F)

1890	68.3°F	1936	72.8°F	1992	67.8°F
1891	69.8	1937	72.4	1993	60.2
1892	66.0	1938	75.0	1994	73.0
1893	67.3	1939	72.4	1995	67.9
1894	70.0	1940	72.8	1996	70.0
1895	67.4	1941	73.8	1997	67.6
Mean	**63.1°F**	**Mean**	**73.2°F**	**Mean**	**67.7°F**
		+5.0°F		**−5.5°F**	

January monthly mean temperature (°F)

1890	17.9°F	1936	31.6°F	1992	23.3°F
1891	38.9	1937	9.9	1993	8.2
1892	26.2	1938	31.5	1994	0.6
1893	23.7	1939	34.6	1995	10.4
1894	26.5	1940	30.0	1996	2.0
1895	27.7	1941	32.0	1997	28.3
Mean	**26.8°F**	**Mean**	**28.3°F**	**Mean**	**12.1°F**
		+2.1°F		**−16.1°F**	

Annual mean temperature (°F):

1890	47.3°F	1936	49.0°F	1992	43.0°F
1891	49.0	1937	48.0	1993	40.1
1892	48.3	1938	50.8	1994	41.5
1893	45.7	1939	50.7	1995	41.0
1894	48.2	1940	51.5	1996	38.7
1895	48.0	1941	50.5	1997	48.0
Mean	**47.8°F**	**Mean**	**50.1°F**	**Mean**	**42.1°F**
		+2.3°F		**−8.0°F**	

the growth of high latitude glaciers and the southern deflection of plant hardiness zones, on which I reported in *21st Century Science and Technology* in Winter 1997/1998.[5]

Any real world model that ignores natural cycles, will be made obsolete. All natural cycles show declining temperature trends and rising precipitation since mid-century, and for the models to be accurate these facts must be accommodated.

Dr. Theodor Landscheidt had forecast the strong temperature decline in his paper, "Long-Range Forecasts of Solar Cycles and Climate Change," which is Chapter 25 of *Climate, History, Periodicity and Predictability*.[6] In Chapter 26 of the same book, Fairbridge and Sanders have forecast on the basis of the 180-year solar retrograde cycle alone, that the next century will be colder, since every other century has been colder, and on that basis alone, the trends in colder data are headed in that direction, so they will probably turn out to be correct.

Natural Global Cooling

Any anthropogenic warming by man-made greenhouse gases is being quite strongly overridden by the natural forcing cycles thus far, and there is no evidence of any anthropogenic warming! The carbon dioxide from industrial sources seems to be going into the oceans and the biosphere, giving a less than expected rise. Global cooling from natural causes is overriding man-made emissions and emissions from vulcanism, such as natural carbon dioxide production. We could have global warming in about 100,000 years, at the end of the next major glaciation, which we seem to be trending into, in these neo-boreal times.

My compilation of July temperatures (with rising precipitation) since mid-century shows that, not only has the temperature rise from the last century across the Northern Tier been eliminated, but so also has the temperature rise from the Pleistocene to the Holocene been eliminated.

In their paper "Late and Postglacial Climactic Changes in the Northern Midwest, USA: Quantitative Estimates Derived from Fossil Pollen Spectra by Multivariate Statistical Analysis,"[7] Thompson Webb III and Reid Bryson show a rise of July temperatures from transfer function studies in Wisconsin and Minnesota from the Pleistocene to the Holocene of 3.3°C, with a tripling of precipitation for July.

Bismarck, North Dakota, has July temperatures decreasing by 4.8°C, with a doubling of precipitation; also, the temperature of Kalispell, Mont., dropped by 3.36°C, with a doubling of precipitation. Bryson and Webb showed a rise from the Pleistocene to 1950 of 4.4°, which has already been more than reversed by the Bismarck decline.

We can say that we are now back to the neo-boreal conditions of the last century, which gave us a Little Ice Age, or even that such a Little Ice Age was, and is, the beginning of the next major glaciation in the terminal Holocene.

Jack Sauers is a geologist based in Seattle.

Notes

1. Ian Campbell and John McAndrews 1993. "Forest Disequilibrium Caused by Rapid Little Ice Age Cooling," *Nature*, Vol. 366 (Nov. 25), pp. 336-338.
2. G. Woillard, 1979. "Abrupt End of the Last Interglacial s.s. in North East France," *Nature*, Vol. 281 (Oct. 18), pp. 558-562.
3. K.R. Briffa, P.D. Jones, F.H. Schweingruber, and T.J. Osborn, "Influence of Volcanic Eruptions on Northern Hemisphere Summer Temperatures Over the Past 600 Years," 1998. *Nature*, Vol. 393 (June 6), pp. 450-455.
4. For a discussion of the axiomatic flaws imbedded in the three-dimensional climate models, see E. Pascali, 1997. "Climate Modeling: Linearization in the Small and the Large," in *The Coming Ice Age*, 21st Century Science Special Report (Nov.).
5. Sauers, Jack, "New Ice Age Looms," 1997-1998. *21st Century Science and Technology* (Winter,) pp 4-7.
6. Theodor Landscheidt, "Long-Range Forecasts of Solar Cycles and Climate Change," 1987. Chapter 25 in "Climate, History, Periodicity, and Predictability," Eds. Rampino, Sanders, et al.
7. Thompson Webb, III and Reid Bryson, "Late and Postglacial Climactic Changes in the Northern Midwest, USA: Quantitative Estimates Derived from Fossil Pollen Spectra by Multivariate Statistical Analysis," 1972. *Quaternary Research*, Vol. 2, pp. 70-115.

NASA SCIENTISTS DISCOVER NEW TOOL TO PREDICT SOLAR STORMS

A team of scientists led by Dr. Richard Canfield announced at a NASA briefing March 9 that they have determined a way to predict, with fair accuracy, when a coronal mass ejection (CME) will occur on the Sun. CMEs spew out a billion tons of solar plasma and its attendant magnetic field. If the plasma from a CME hits the Earth's magnetosphere, geomagnetic storms occur and can disrupt satellites in near-Earth orbits, and cause power surges and failures in electricity grid systems.

After studying 50 X-ray images per day for the years 1993 and 1997, the scientists concluded that sunspots that develop an "S"-shaped structure, seen near solar maximum—the phase we are now entering—are most likely to erupt into CMEs. The X-ray images were transmitted by the Japanese Yohkoh satellite, and were used to create movies that show the development and discharge from the sunspot region. Canfield and his associates reported that if sunspots are monitored for these S-shaped structures, space weather forecasters may be able to provide a four-day warning for geomagnetic storms. By the time the CME is observed, only a few hours' warning time is possible.

Hugh Hudson and David McKenzie

The S-shaped region seen in this X-ray image of the Sun, erupted into a coronal mass ejection.

NEW STUDY SHOWS THAT PCBs DO NOT INCREASE RISK OF CANCER

People exposed to higher-than-natural levels of polychlorinated biphenyls (PCBs) do not have an increased risk of cancer, according to a study by Dr. Renate Kimbrough, of the Institute for Evaluating Health Risks. PCBs were widely used by industry because of their insulating and flame-resistant properties. Kimbrough analyzed 7,000 people who worked at General Electric plants in New York from 1946 to 1977, and who were exposed to PCBs in the manufacture of electrical insulation and electrical capacitors. The study results showed that these workers had a lower rate of death from cancer than the rate in the general population. "Even long-term human exposure to PCBs at higher levels than are found in the environment is not related to an increase in deaths from cancer or any other disease," Kimbrough said.

Working at the Centers for Disease Control, Kimbrough had published a study in 1975, that showed an increase in liver tumors in laboratory rats given an extremely high dose of PCBs in their diet. This fueled environmentalist scare stories about PCBs, which led to their ban by the EPA in 1979. The Environmental Protection Agency (EPA) estimated that by 1985, almost $1 billion had been spent to remove and dispose of PCBs in the United States. The EPA is trying to downplay Kimbrough's new study and is currently in a battle with General Electric over the presence of PCBs in the sediment bed of the Hudson River.

KYRGYZSTAN PRESIDENT: 'THE GREAT SILK ROAD' IS OUR FOREIGN POLICY

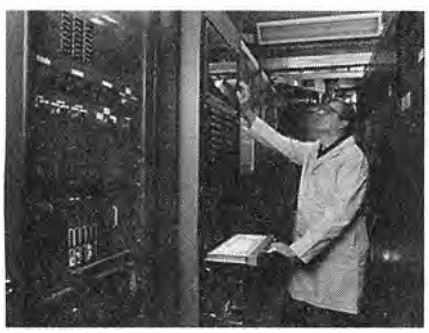
Askar Akayev, President of the the Kyrgyz Republic, announced in the March 10 issue of the Russian daily *Nezavisimaya Gazeta* that his country's foreign policy doctrine was to pursue the diplomacy of the Great Silk Route.

In a front-page article, Akayev wrote: "The Great Silk Route has a history of several thousand years, during which, in ancient times, it provided the trade and economic, cultural and humanitarian, and political and diplomatic links between East and West and, to a certain extent, North and South. . . . For this long period of time, the Great Silk Route was the bridge between countries and civilizations. . . . Trade was carried out on it, which catalyzed the development of crafts. Travellers and researchers made a huge contribution to the development of science, as they studied the countries and peoples, inhabiting the lands along the entire Route. . . .


Laurence Hecht

Askar Akayev: "The idea of a rebirth of the Great Silk Route has broad international support." Here, the President of the Kyrgyz Republic at a National Academy of Sciences meeting in 1993, honoring Andrei Sakharov.

"The Great Silk Route was of incalculable importance for establishing and maintaining diplomatic relations between the centers of political life, the major nations of Europe and Asia. . . . On the eve of the new, third millennium, the idea of a rebirth of the Great Silk Route has broad international support. . . . The sustained and dynamic development of political and economic relations today is inconceivable without friendship, partnership, trust, and mutually beneficial relations, among all the nations of the Silk Route region."



American Superconductor

An engineer checks the monitoring equipment inside a trailer housing the superconducting electromagnetic electricity storage system. The helium cryostat containing the superconductor coils is in the background.

FIRST SUPERCONDUCTING ELECTRICITY STORAGE SYSTEM SHIPPED

An important large-scale application of superconductivity is now a commercial product, American Superconductor announced in March. The company shipped its first industrial Magnetic Energy Storage system to the STEWEAG electric utility in Austria. Electricity, in general, cannot be stored, and has to be continuously produced for instantaneous use. When there are even slight interruptions to the flow of power, or a drop in the voltage, industrial facilities can come to a standstill, as their electrical equipment shuts down into a safe mode, to protect from surges. For the aluminum foundry in Gleisdorf, Austria, served by the STEWEAG utility, this problem is severe during the spring, when storms produce much lightning.

The superconducting electromagnetic electricity storage system will be housed in a portable trailer at the foundry, and will sense any voltage reduction in the plant's delivered power, usually lasting only two seconds. When a momentary disturbance is sensed, supplemental power will be provided, preventing a plant shutdown. The magnet, made of low-temperature superconducting wire, will be powered up, and will remain so indefinitely without degradation, until the power is needed. Conventional copper wire would dissipate the energy, producing waste heat, and would have to be continuously —and uneconomically—repowered.

GERMAN COURT RULES FOR FARMERS, AGAINST GREEN WETLAND PLAN

The Lower Saxony State Court in Lüneburg, Germany, ruled Feb. 22 against an environmentalist project to establish a wetlands nature park along the Elbe River basin, and in favor of the plaintiffs, a farmer and his wife. The farmers charged that the nature park project would eliminate 40 percent of their land, and thereby threaten their basis for existence. Nature parks cannot be established in regions which for centuries have been cultivated by human beings, and which for as long a period have been the basis for economic and social life in a region, the court said. This particular wetlands park project had been pushed through several years ago by Greenpeace and other Green organizations and the state's then Environment Minister, Monika Griefahn, a former Greenpeace leader.

SAM WHITNEY, FOUNDER OF FOOD IRRADIATION PLANT, DIES

Businessman Sam Whitney, who organized and headed the Vindicator of Florida food irradiation plant near Tampa, died of lung cancer Sept. 22, 1998, at age 75. Sam got involved in building the irradiation plant after the Environmental Protection Agency decided to ban the chemical ethylene dibromide (EDB) as a postharvest fumigant in 1985. He piloted the plant through the long technical approvals process, and became an outspoken advocate for the technology, often brandishing his humor as a weapon in a fight he was determined to win against anti-nuclear misinformation and fear.

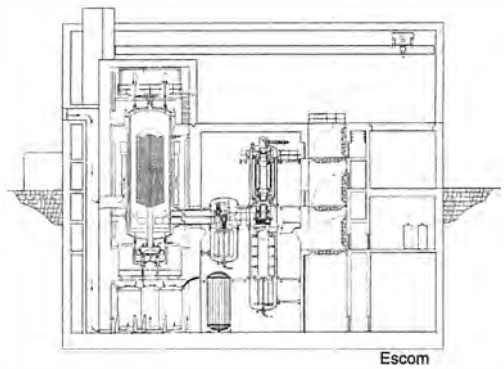
As Sam put it in a 1991 interview with *21st Century:* "I've been a fighter all my life. I was born in a coal mining community near Paducah, Kentucky. I went into the service, then I got a job in Nevada, and my company transferred me [to Florida] in 1955. And in 1959, I went into business for myself. My dad was an unemployed coal miner, so all I've known is fighting. . . . We fought to eat. . . . I have 14 grandchildren, and I don't want them to have what I've had. . . . I've had salmonella poisoning at least three or four times. . . . "

Sam Whitney speaking out for food irradiation in 1991.

Sam's voice was gravelly, and his tone often gruff, but he was a golden soul—a combination of vision, compassion, and fighting spirit that represents the best of America. He did not back down on food irradiation, although it was tough going against a well-funded, unscrupulous opposition. For this, we owe him a great debt of gratitude. We will miss him.

SOUTH AFRICA PLANS TO PRODUCE 30 HTR MODULES PER YEAR

The South African power supplier Escom, the fourth largest in the world, will build a high-temperature gas-cooled reactor (HTR) of the German pebble-bed type near its Koeberg nuclear power plant, which is close to Cape Town. The German daily *Die Welt* headlined its Jan. 20 article reporting the news, "Stopped in Germany, Now Being Built in South Africa," and pointedly noted the inherent safety features of the HTR reactor, whose development was shut down in Germany 10 years ago, under anti-nuclear pressure. Once the first plant is in operation, *Die Welt* reports, the country plans to produce 30 HTR modular reactors a year, each 114 MWe, of which 20 will be exported.



Escom's pebble bed modular nuclear reactor design uses helium as the working fluid, 60-mm fuel pellets, and a closed-cycle gas turbine system in place of the conventional steam cycle.

TAIWAN APPROVES FOURTH NUCLEAR POWER STATION COMPLEX

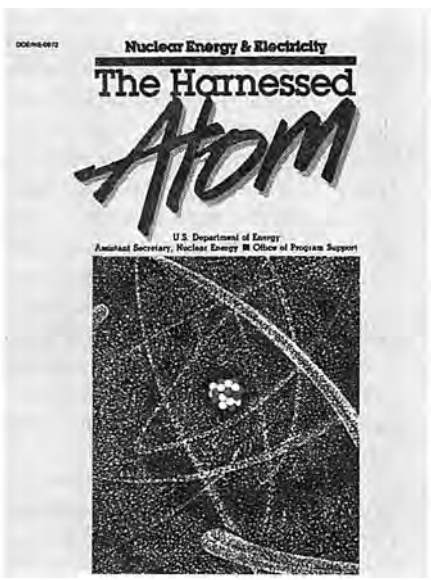
Not yielding to anti-nuclear protests that sparked riots outside parliament in 1996, the Atomic Energy Council of Taiwan approved the construction of the fourth set of nuclear power plants on the island in mid-March. The Council studied the issue for 17 months, and had more than 100 experts assess the safety of the plant design, amassing 9,000 pages of documentation. It concluded that the design "adequately ensured public health and safety." The two reactors will be supplied by General Electric Company, under a $1.8 billion contract. The total cost of the project is $4.8 billion. The reactors will be built in Taipei County on the Pacific coast. The first unit is planned to be on line in 2004 and the second, a year later. Taiwan has six other reactors, accounting for 24.8 percent of the island's electricity.

NEW FUSION EXPERIMENT BEGINS OPERATION AT PRINCETON LAB

Secretary of Energy Bill Richardson cut the ribbon Feb. 26, marking the beginning of operations on the National Spherical Torus Experiment (NSTX) at the Princeton Plasma Physics Laboratory (PPPL) in New Jersey. Unlike conventional tokamak fusion experiments, which produce a plasma in the shape of a donut, the NSTX produces a spherical plasma with a hole through its center—a spherical torus. Scientists expect this configuration to have several advantages, including the ability to confine a plasma at a higher pressure, for a given magnetic field. The new device will build on the results from the Tokamak Fusion Test Reactor (TFTR), which was shut down last year, mainly because of a lack of funds. TFTR had attained a record 510 million degree temperature plasma, and 10.7 million watts of fusion energy. The NSTX was designed and constructed jointly by PPPL, Oak Ridge National Laboratory, Columbia University, and the University of Washington in Seattle. Fourteen laboratories and universities will participate in the research program.

DOE FILM ON NUCLEAR POWER AIMED AT 6TH THROUGH 8TH GRADERS

Splitting Atoms—An Electrifying Experience is an 11-minute video produced by the U.S. Department of Energy that explains the importance of nuclear power in generating electricity and some basics of how electricity and power plants work. The video is narrated by three lively young teenagers, and, aside from some unpleasant background music, is a brief but competent treatment of the subject. Designed as a companion to a 1986 publication for students, *The Harnessed Atom,* the video won the International Television Association's Bronze Reel Award for video and film excellence last year. Copies can be obtained from the DOE Office of Nuclear Energy's public information office at (301) 903-1632.



The Harnessed Atom *is the DOE's workbook on nuclear energy for middle school teachers.*

Let's Simplify the Concept of Radiation 'Risk'

by Jacques Pradel

Ecological fundamentalism has reached the height of ridiculousness with its regulations on very low doses of radiation and zero discharge.

Intelligent people have worked out the principle of ALARA, which stands for "as low as reasonably achievable," concerning radiation discharges, but it would be a mistake to leave its application to just anybody. The "R" in ALARA has proved to be a loophole into which have jumped fanatical extremists whose reasoning remains, deliberately or not, very primitive.

Everyone knows that in the field of measurement, a zero value makes no sense, yet a high and noble aura remains attached to the quest for such absolute purity. In any case, the conclusion reached for any amount of radiation emission is "guilty." It is difficult to reassure even honest people, and to convince them that *very low exposures are not dangerous below a given threshold.* We shall restrict ourselves here to dealing with the case of exposures to ionizing radiations, but we must realize that the problems are, or will be, the same for most of the other hazards to which individuals are exposed.

How is the situation described at present?

The no-threshold linear law is now in effect. This assumes that a detrimental effect observed at a high radiation dose, has a probability of occurring at a lower dose. Furthermore, it is assumed that this detrimental effect decreases linearly with the dose, and tends toward zero when the dose also tends toward zero. The result is that any dose of ionizing radiation, however minimal, is not considered devoid of risk, and that when a large number of individuals is exposed, it is likely that a certain number of cancers may occur, even if the probability of this is extremely low at an individual level.

These cancers are hypothetical but, of course, this qualifier is rapidly *forgotten.* Epidemiological studies will never be able to prove that these cancers do, or do not, exist, owing to their low hypothetical probability.

How can the entire population be convinced to accept this hypothetical "hazard"?

We must admit that such a presentation of the situation makes its acceptance excessively difficult. Indeed, being responsible for even one additional cancer out of a million inhabitants—even if 20 percent of these cancers will occur without any radiation exposure occurring—is very difficult for a nonspecialist to accept. However, for ionizing radiations, as for many other materials with a potential impact on health, specialists have *natural references* at their disposal, enabling them to reassure the population at large, without going into complex considerations based on statistical data and more or less understandable health-related hypotheses.

The nuclear lobby, which has the responsibility for explaining radiation to the public, may be so unduly influenced by the financial manna and the media coverage potential related to the explaining the potential risks resulting from nuclear activities, and related fears, that this group is prevented from thinking about explaining risk in an understandable way.

A Change in Language

My recommendation is that *all those participating in this lobby should change their language and use other risk assessment units.* To communicate successfully, simple or even simplistic explanations must be given, even if this may shock some specialists at times. In an excellent article published in the March-April 1998 issue of the *Revue Générale Nucléaire,* Swedish scientist Gunnar Walinder shows how, thanks to judicious examples based on simple comparisons, the exaggerated nuclear fears can be minimized.

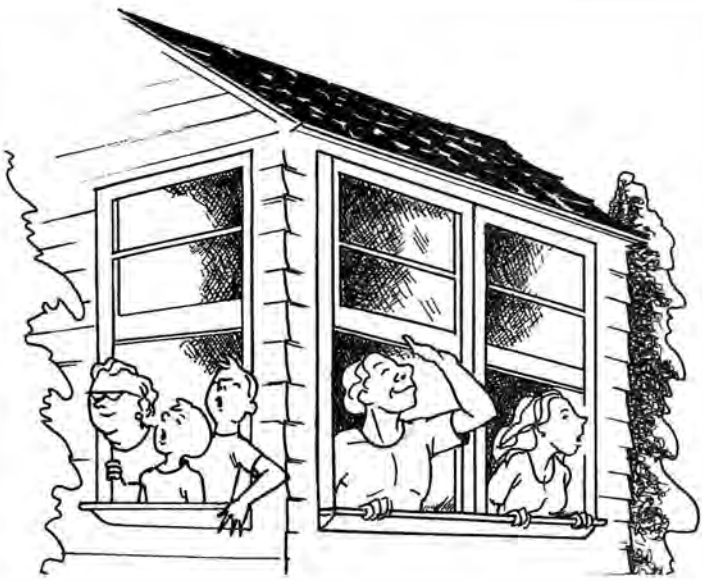
I propose the use of two reference examples of simple units of assessment of the effect of low-dose radiation.

The first uses the variation of the dose caused by cosmic radiation, according to elevation, and adopts for a dose intensity unit, *the additional altitude meter.* Thus, the radiation measure of 1 microsievert per year is replaced by 4 additional altitude meters—with each altitude meter being defined as the equivalent in height of two floors of a building.

This gives us a valuable reference with which to assess those studies carried out by masterminds who sit comfortably in their armchairs contemplating the globe, and who conclude that a population of some hundred million inhabitants will be exposed on an average to some 10^{-9} Sv/year from the radon emitted by the residues of the processing of uranium ore for the next 10,000 years. Further, on this basis, these pundits foresee some hundreds of supplementary cancers added to the tens of millions normally expected.

It seems to me much more understandable and acceptable to present the case as follows: The dose received by this population (as a result of the residues from uranium ore processing) corresponds approximately to what the population would receive if the elevation of its homes were to rise by about 1 centimeter (the equivalent of 2 to 3 10^{-3}mv/year). This type of argument has, moreover, been used in other, more extreme cases (such as carbon-14), in which the rise in equivalent altitude was of a tenth of a thousandth of a millimeter.

Jacques Pradel is the former president of the French Society for Radiation Protection, and former official in radiation protection at the French Atomic Energy Commission. This viewpoint originally appeared in a review of the French Nuclear Society.



If we base the radiation dose unit on the dose received from the radon concentration in our dwellings over one year, then the average dose received from uranium processing would be the equivalent of a stay in our dwellings of 30 seconds per year. Consequently, breathing out the window 30 seconds longer a year cancels out this effect.

The second reference point I propose is provided by the radon concentrations in our dwellings. The dose unit used is the *unit of time during which we stay in these dwellings.* We can take as a basis for this, the average concentration of 50 bequerels/cubic meter, which involves an exposure of about 1 millisievert per year. (Note that the International Committee on Radiation Protection recommends action only for concentrations that are four to eight times higher than this.) A year's stay in our dwellings thus becomes a dose unit.

In the uranium ore example, the average individual doses of about 10^{-9} Sv/year correspond to a stay in our dwellings of 10^{-6} years, or about 30 seconds per year. *Consequently, breathing out of the window 30 seconds longer once every year, cancels out the effect under study.*

These two simple units, additional meter in altitude, and second of stay in our dwellings, used wisely, may make it understood that, in some cases, the "R" of ALARA means *ridiculously,* instead of *reasonably*—which is bad for the correct use of this principle and works against its purpose.

We may also recall the unit already mentioned elsewhere (*Industry and Environment,* No. 190, June 18, 1998, p. 4) concerning surface contaminations: namely, the number of square meters a person can lick every year without exceeding the limit of 1 millisievert of radiation per year. (The limit of 4 becquerels per square centimeter mentioned for transport casks thus becomes several lickable square meters every year.)

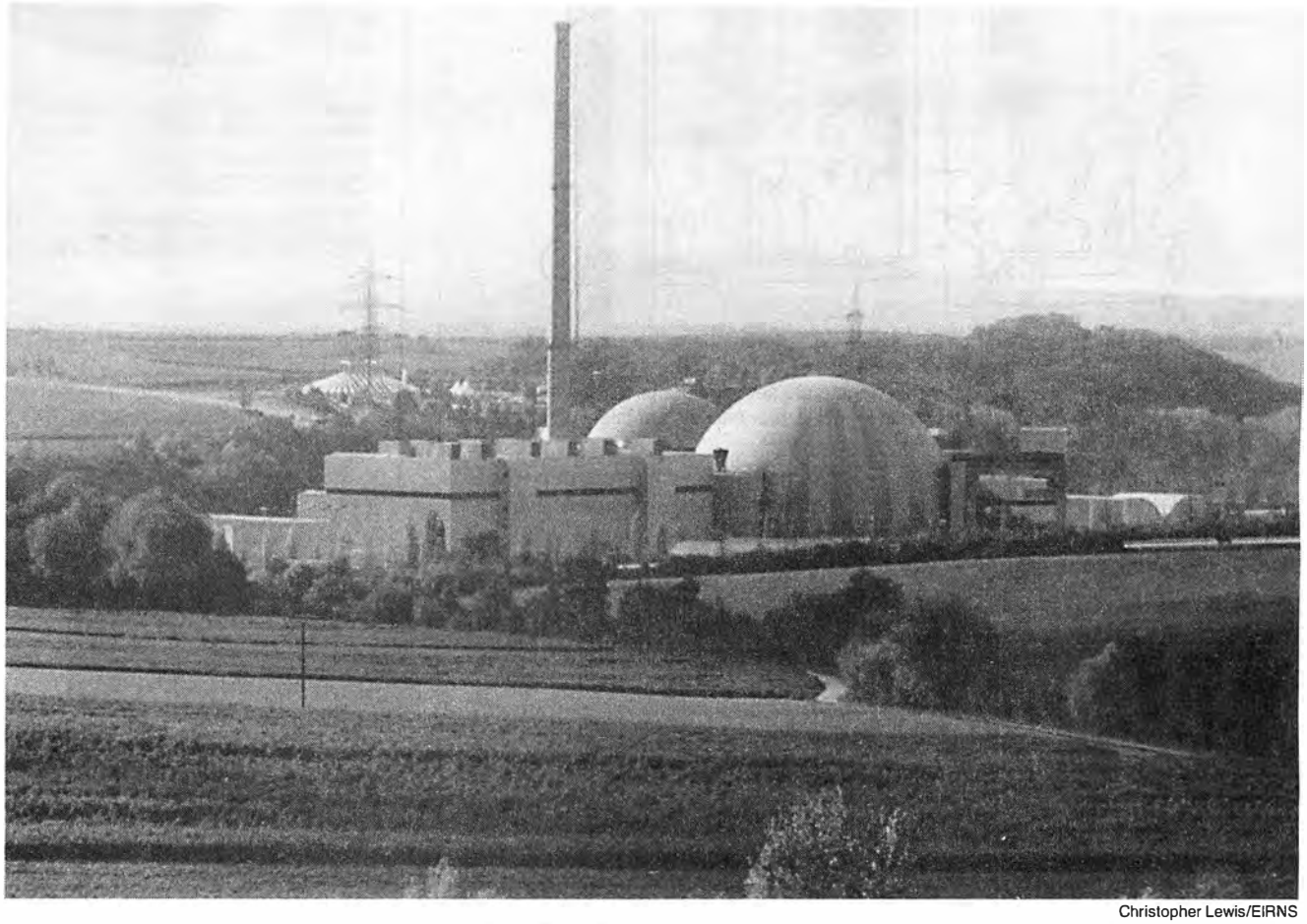
As for zero discharge, which also relies on considerations relative to the very low doses concerning large populations, it is not at all *reasonable.* We shall only advise its advocates to be very careful as they expose themselves to an epidemic of fecalomas and other blockage by carrying out a personal zero-discharge policy.

Answers to 'The Real Gore'
From Letters, page 4

(1) Gore
(2) Unabomber
(3) Gore
(4) Gore
(5) Unabomber.

German Government Retreats from Plans to Shut Down Nuclear Energy

by Rainer Apel



Christopher Lewis/EIRNS

In a stunning turnaround, German Environmental Affairs Minister Jürgen Trittin, a radical Green Party spokesman, announced Feb. 22 that his draft for a new nuclear technology bill no longer contained the original proposal to ban all nuclear reprocessing in January 2000. Nuclear power now supplies 34 percent of Germany's electricity. Here, the Neckar Westheim nuclear plant.

On Jan. 25, 1999, German Chancellor Gerhard Schröder announced that his government had dropped plans for immediate implementation of its policy to eliminate the use of nuclear technology. This was a major retreat for the new coalition government of the Social Democratic Union (SPD) and the radical environmentalist Green Party, which had been elected in September 1998 on a strong anti-nuclear platform, including a ban on the reprocessing of spent nuclear fuel by January 2000.

Schröder's announcement was elaborated the next day, at a meeting of the nuclear power roundtable of industry, labor, and government representatives in Bonn: There will be no target date for a general ban on nuclear energy use. Instead, individual timetables for the shutdown of each of the 19 nuclear plants, which now provide 34 percent of Germany's electrical power, will be negotiated in tripartite (industry, labor, and government) working groups assigned for each of the plants.

Under this plan, industry will be given several years to come up with alternatives (1) to the reprocessing and transport by rail of nuclear waste, and (2) to the reliance on nuclear energy altogether. Details of how this would work, will be defined at another tripartite roundtable session in mid-March.

This compromise is a severe setback to the radical currents of the "Red-Green" government and to the environmentalist movement, which insist that the withdrawal from nuclear technology

begin on Jan. 1, 2000. The Green Party, the Social Democratic Party's government coalition partner, has protested, but so far it has chosen to swallow the concession. Most spectacular, Environmental Affairs Minister Jürgen Trittin, a Green Party front-man for the anti-nuclear radicals, declared Feb. 22 that his draft for a new nuclear technology bill no longer contained the original proposal to ban all nuclear reprocessing as of January 2000.

This retreat on the part of the German government and, particularly, of Trittin, was brought about by a combination of strong resistance from labor, which threatened utility strikes, and from several state governments and the nuclear industry, which threatened legal action against the federal government.

Also, ironically, the British government, whose Labour majority has a green agenda, was one of the leading catalysts of the Jan. 25 decision by Chancellor Schröder to invoke his "Chancellor's guideline privilege" and overrule his coalition partner.

The British Hard Line

On Jan 20, Jürgen Trittin travelled to London to discuss German plans for an end to nuclear reprocessing with British Trade and Industry Secretary Stephen Byers. Byers told Trittin plainly that, if the German government stuck to its plans, which would invalidate long-term contracts into the year 2014, it would affect close to 4 billion deutschemarks (roughly $2.5 billion) of business promised under these contracts to Britain's Sellafield reprocessing facility. The British view, Byers said, is that "it would be wrong for the company to suffer from a change in German policy over which they have no control. But I also stressed that the costs of that decision should not be borne by BNFL [British Nuclear Fuels, Ltd.], which had entered into legally binding contracts in good faith."

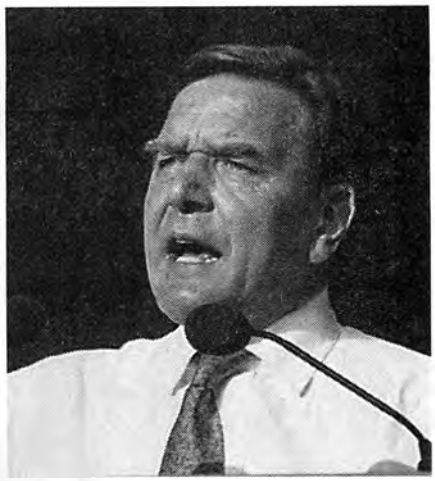
Byers said, "I made it clear that if the 650 tons of German spent fuel in store at Sellafield were not to be reprocessed, then it would have to be returned to Germany. The U.K. will not act as a storage depot for nuclear material." When Trittin argued that a change of government and, thereby, of nuclear policy in Germany, in his view, was a *force majeure* that invalidated all signed contracts, Byers shot back, "The German government is not God; therefore, there is no *force majeure* involved here."

The hard-line approach of the British seemed to have made an impact on Trittin, who had had a much more sympathetic response from his French colleague, Environmental Minister Dominique Voynet, a few days earlier. When back in Germany, Trittin announced that he was confident that his view would prevail over that of the British side. However, in the meantime, the French government also woke up, declaring on Jan. 21 that it would insist on full monetary compensation for its own reprocessing contracts with Germany, involving close to 9 billion deutschemarks.

The London affair demonstrated to German industry that the hard-line approach against Trittin and his supporters works. Managers in the nuclear sector then began to put pressure on Chancellor Schröder, whom several of them know personally. In memos and meetings between Jan. 21 and 25, nuclear industry managers made clear to Schröder that he would face legal action and claims for compensation and penalties for breaking treaties, in the range of several billion deutschemarks. It also became known in Bonn that an internal review on the issue at the Ministry of Justice had come to a similar conclusion, urging the government to act strictly by the law, in order to avoid such compensation payments.

A French Nuclear 'Welcome'

The German nuclear workers, who are organized in the public sector union OETV, were remoralized, less by the British "no" to Trittin, than by the treatment that Daniel Cohn-Bendit, a leading German Green, got in France, when he visited the nuclear reprocessing plant at La Hague on Jan. 19. Cohn-Bendit, who heads the slate of the French Greens for the June 13 elections for the European Parliament, ran into deep trouble when he tried to enter the site: Several hundred enraged French nuclear workers blocked his way and told him to get lost, because he and his Green co-thinkers were about to eliminate their jobs at La Hague. Cohn-Bendit was pelted with eggs and had to be escorted onto the site by French riot police. In the evening, Cohn-Bendit was forced to call off a public meeting with Greenies in nearby Cherbourg, when



Christopher Lewis/EIRNS

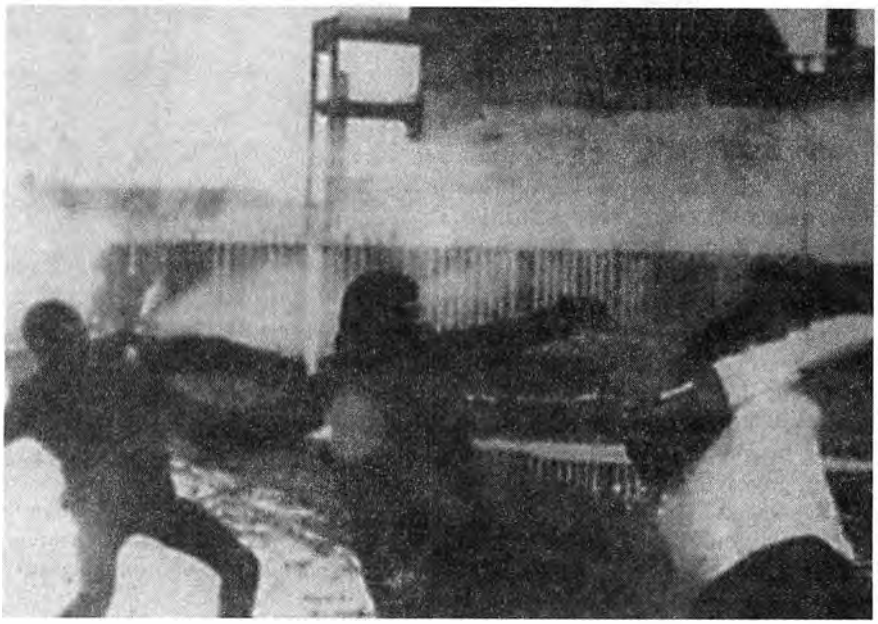
German Chancellor Gerhardt Schröder's "Red-Green" alliance is shaky, as unionists challenge its anti-industrial agenda.

utility workers threatened to turn the power off in the building where the meeting was to be held.

The affair was widely covered by German media, and caused German workers to reflect on their Green problem as well. In a discussion with this author on Jan. 20, Rainer Dücker, chairman of the factory council at Preussen-Elektra, one of Germany's leading nuclear power producers, said that he wished "that some of that French spirit would also be shown here, in our country," and that German workers would become more active against the Greens.

Dücker said that nuclear workers would refrain from public actions before the scheduled Jan. 26 roundtable talks in Bonn, in order to give Chancellor Schröder and the Social Democrats a last chance to push back Green demands for an instant withdrawal from nuclear technology. But, should the SPD make the exit from nuclear technology official government policy, he said, Chancellor Schröder would run into a big conflict with labor. The nuclear sector workers (there are 40,000 of them) would make the government feel what they think of this policy, Dücker said.

Asked whether they would go as far as the miners did in early 1997, when they marched on the Bonn governmental district, Dücker said that the power sector workers have "other, far more effective means. . . . Just imagine, for example, an important soccer match, with all the broad attention that that has in the population, and immediately after the match



Bayenkurier

Green terror: Masked ecoterrorists attack a German nuclear plant in 1986, in tactics reminiscent of how the Nazis came to power in the 1920s and 1930s. While many chose to remain silent at that time, the LaRouche political movement in Germany waged a vigorous pro-nuclear, anti-terrorist electoral campaign.

is opened, the power to the stadium is turned off and stays turned off for the next 90 minutes. This will make clear to everybody what it would be like, if an important sector of our power supply is taken off the net—as the Greens want to do, and would do, with their policy."

Dücker and other labor union members, interviewed by this author, have hinted that selective power outages might also be used against other targets, similar to what was done in Cherbourg, which ruined Cohn-Bendit's planned panel against nuclear power, on Jan. 19.

Energy Dependency and Blackmail

German labor leaders view the French labor protests against the Greens, as justified. "We have a new generation of nuclear power plants, the EPR [Enhanced Pressurized Water Reactor], which is a joint Franco-German project, and if we say no to nuclear technology, that means the end for the German share in that promising, future-oriented technology," Dücker said.

Time Running Out for 'Red-Green' Alliance?

The retreat of the German Greens from some of their environmentalist programs is a measure of the pressures on the ruling "Red-Green" alliance.

The most forceful flank against the Greens recently has been coming from the labor unions. More and more workers are getting enraged at the fact that, while the economic depression is already killing several hundred thousand new jobs every year, the Greens and their ecology projects are about to kill several hundred thousand more industrial jobs. And, what is very important for Germany, workers are beginning to take to the streets.

On Feb. 4, about 4,000 nuclear power workers and other unionists took to the streets of Stade, protesting Environmental Affairs Minister Jürgen Trittin's anti-nuclear policy. On Feb. 19, more than 250 leaders of factory labor councils from the power sector and supply industries, convened in Munich for a national conference in defense of nuclear technology.

On March 9, a larger national rally of the workers in support of nuclear power is scheduled in Bonn. The fact that the government called off a national roundtable meeting in Bonn, planned for the same day, is telling: The "Red-Green" government of Chancellor Gerhard Schröder (Social Democrat) is still committed to abandon nuclear technology, but it does not want to have such a roundtable in an environment where thousands of angry workers are encircling the government district in Bonn. This would force the Chancellor to make concessions which he does not want to make.

The Chancellor has felt compelled, on prior occasions, to overrule his Green minister on aspects of the planned nuclear technology bill, to calm the population. And, he felt compelled to cancel his attendance at the Feb. 20 celebration of the 100th "birthday" of the German League for the Protection of Nature. The chairman of the league, Jochen Flasbarth, had been on national television a few days before, attacking shipyard workers in the Emsland region who plan to protest ecologist sabotage of investments in river regulation projects.

Schröder told Flasbarth that he could not attend the ceremony, at a time when workers had justifiably expressed concern about the future of their jobs. Attending the ceremony, would be misread as a signal that the Chancellor was not paying attention to jobs.

Schröder's effort to placate labor's concerns is not a result of a change of views, nor a matter of principle for him, but sheer opportunism that forces him into tactics to calm labor and ecologists alike, to keep the shaky balance of his own government in Bonn. The government has come under so much pressure from labor, that it cannot risk being "misunderstood" by workers. There is growing sympathy for large labor union strikes, and in the state of Hesse, the first "Red-Green" state government was voted out on Feb. 7.

It seems clear that time is running out for the Green-Social Democratic alliance. *—Rainer Apel*

When asked about other nuclear technologies, such as the fast breeder and the high-temperature reactors, Dücker commented that it is highly regrettable that politicians lack the courage to get these technology projects built in Germany. He said that although the present government majority in Bonn is against nuclear technology, he is personally confident that the majority of the German population would vote for nuclear power, if properly informed about the consequences of banning it.

"If Germany really walked out on nuclear technology now, it would be forced to return to it, after one generation, out of despair over secure power supplies," he said. It would be a real catastrophe, and everybody would feel it, he said. Germany would be "blackmailed from abroad with dictated energy prices," if it had no secure minimal national power supply of its own, which is only possible with modern nuclear technology.

Christopher Lewis/EIRNS

Metalworkers demonstrating in Mannheim against ABB in 1998. Now, utility workers are considering protests that will turn out the lights for a specific time, to make the point that reliable electric power depends on keeping nuclear plants open.

Nuclear Activation Required

Although the Red-Green government suffered a setback, and was forced to retreat, it has not suddenly become pro-nuclear. The next round of conflicts is inevitable. A defeat of the anti-nuclear movement, and a restored perspective for the development of nuclear technology in Germany, can only be achieved by an activation of those pro-nuclear people who have remained all-too-silent over the past years. Many have been frustrated at the politicians' sell-out of principles and at the concessions made to the Greens, but kept silent because of fear of intimidation or even of terrorism, like that launched by the Greens at the peak of their anti-nuclear protests in the mid-1980s. What Germany has been lacking—outside of the LaRouche political movement, which has been an uncompromising defender of nuclear technology and an advocate of hard-line approaches against the Greens for the last 20 years—is a sufficient number of German workers, industrial managers, and politicians who show a commitment to fight the issue through.

For example, inside the SPD, there are many who disagree with the anti-nuclear course, but are too timid to go public on the issue. There are too few political leaders like Günter Supper, a nuclear engineer who joined the SPD after the oil crisis of 1973, when the party leadership still was in favor of nuclear energy. Supper, who lives near Neuwied, in the state of Rhineland-Palatinate, was part of the engineering workforce that built up the large nuclear power complex at Biblis, in the neighboring state of Hesse, in the early 1970s, and was later involved in the construction of the Mülheim-Kärlich nuclear plant, in his own state. This plant was closed down in 1988, shortly after its completion and a test-run of several months, under the impact of the post-Chernobyl hysteria, in which the SPD played a leading role.

Resisting the temptation to quit the party membership, Supper then chose to stay, in order to be a voice for pro-nuclear views inside the party. This, however, has not earned him merits; quite the contrary: In mid-January, Supper learned that his name was eliminated from an inner-party proposal for a slate for regional elections. He found out that this was done by regional SPD leaders because they decided that his views were not opportune.

This incident is typical of many which have occurred inside the SPD nationwide. But unlike other SPD party members who retreated under pressure into anonymity and inaction, Supper took his case to the press, circulating statements that made public the inner-party practices of the SPD. In one of these, he termed Trittin a "Rasputin" behind Chancellor Schröder, and called upon his fellow Germans to learn from the "French nuclear power workers [who] would, if faced with such attacks on their integrity, as they are launched here, rather show the population how quickly the lights can be turned off!"

The fact that the labor leader Dücker also spoke of such selective power-turnoffs, shows that the potential is there for a forceful labor offensive against the Greens. Whether the ferment will be tapped, will decide whether nuclear power has a future in Germany. Those who want to fight the Greens on that issue, have a loyal ally in the LaRouche movement in Germany.

Rainer Apel is a Bonn correspondent for the Executive Intelligence Review *magazine, and a version of these articles appeared in EIR.*

EURASIAN LAND-BRIDGE: KEY TO ECONOMIC RECOVERY

Will the U. S. Join in the Land-Bridge?

by Marsha Freeman

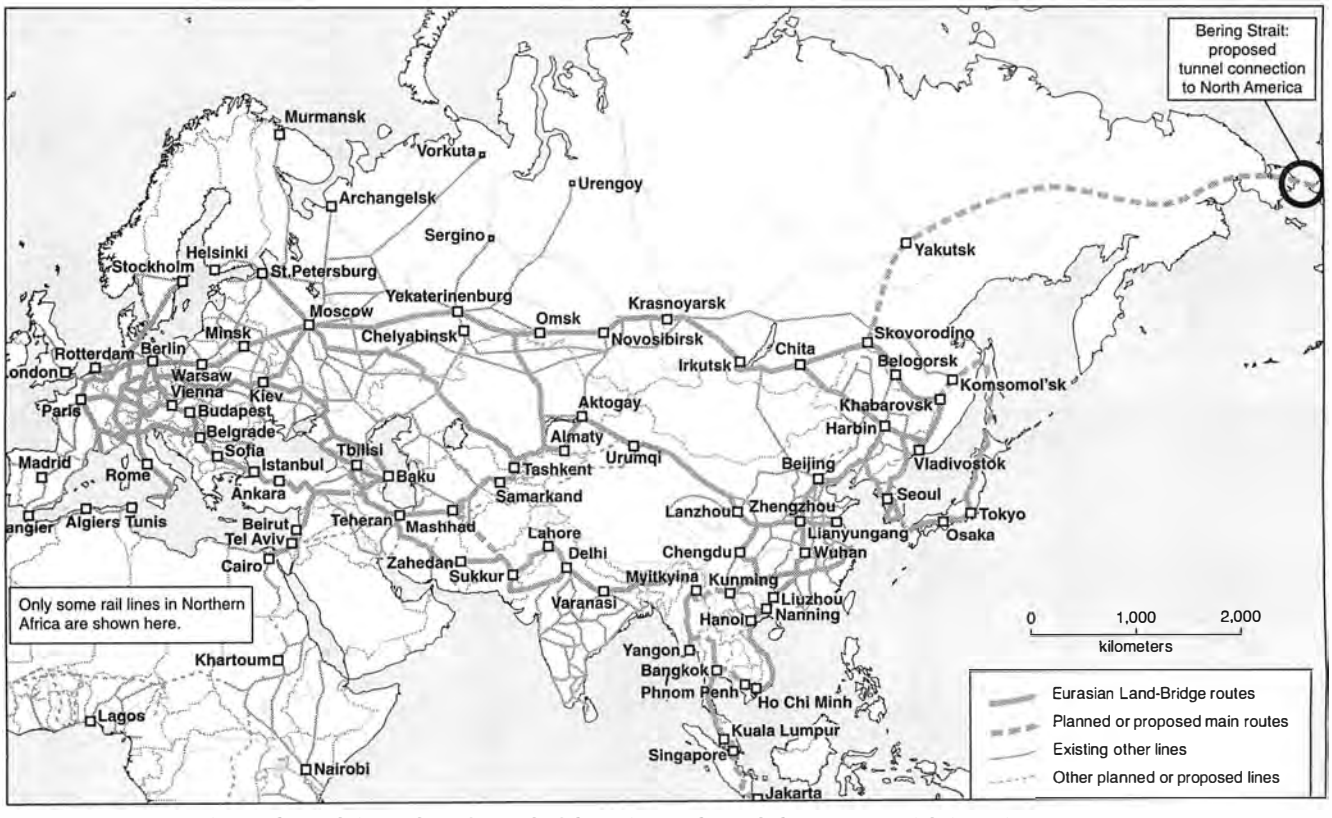
The United States stands today at the threshold of the greatest mobilization of scientific and economic resources since the end of World War II. Nations in Asia, led by the government of China, have cast off thoughts of adhering to the self-destructive austerity and debt policies of the current international financial system. Instead, they are joining together to build a modern industrial land bridge from Europe through Asia—an 11,000-mile development corridor, stretching from the east coast of China to the port of Rotterdam in Europe.

The vast natural and human resources in the nations of Central Asia, Russia, the Indian subcontinent, and East Asia are being engaged in the building of modern transportation and communications links, the exploitation of energy and other natural resources, the building of new industries along the historic Silk Road, and the construction of new cities.

These projects will succeed only if the advanced scientific and engineering capabilities of the United States, Europe, and Russia are applied. The United States has the opportunity—and the responsibility—to technologically revolutionize and restart production in its creaking and closed factories, and re-employ the idle workers and scientists and engineers from its military, nuclear, and aerospace sectors. In this process, it can join the growing number of nations that are determined to return to an "American system" of political economy, based on providing an increasing standard of living for its citizens through investment in infrastructure, science, and education.

Strategic Engagement

President Clinton, through his policy of "strategic engagement" with the leadership in China, has attempted to establish trust and a working relationship with the world's most populous nation. He has been thwarted at every turn by opponents in the Congress, so-called conservative think tanks, and some military strategists,



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

The Land-Bridge offers vast opportunities—and a life-line—for U.S. science and technology industries.

who want to return to Cold War geopolitics, using China as the new "enemy image." He has also been surrounded by anti-nuclear and anti-progress "leftist" ideologues, led by Vice President Al Gore, who are trying to sabotage U.S.-China collaboration in the advanced technologies, such as nuclear power, upon which the Eurasian Land-bridge must be built.

Last spring, an "exposé" in *The New York Times* was blown up into a major strategic assault on the President's China policy, when accusations were made that the launching of U.S.-built commercial communications satellites on Chinese rockets had resulted in the transfer of technology that could be used by the Chinese military.

Chinese President Jiang Zemin visited Russia and Japan in November 1998, gaining agreement from both countries on the Land-Bridge policy for large-scale infrastructure development in Eurasia. Here, Jiang (left front) in the Science City of Novosibirsk, where he gave a major speech on science and technology as the driving force for economic development. (See 21st Century, *Winter 1998-1999, p. 23.)*

This attempt to cripple or stop commercial relations between the United States and China in this crucial high-technology sector, and attempt to have China perceived as a "rogue" nation out to harm the United States, was unfolding at the same time that the Republican majority in Congress was blasting Chinese attempts to influence U.S. elections through campaign contributions. China was being accused of violating arms control agreements, and self-righteous religious fakers were feigning concern for the human rights of Chinese dissidents.

Then, in early March, a month before Chinese Prime Minister Zhu Rongji was to visit the United States, *The New York Times* began the scare campaign that Chinese-born scientists working at American nuclear weapons laboratories had been stealing nuclear secrets for years, endangering the security of the United States. There is no evidence that this is so, and no one has been arrested and charged.

While President Clinton's engagement policy with China has been under attack from many sides, he has held fast to the idea that discussing differences and cooperating in areas of fundamental agreement should be the mainstay of international relations of such importance.

Now, U.S. policy must move from "constructive engagement" to active involvement in the great economic development projects that are bringing together nations from Asia and Europe.

Chinese Infrastructure Projects Looking for U.S. Technology

by Richard Freeman

The U.S. Commerce Department will travel to China in late March, on invitation by the Chinese, to follow up on initiatives for U.S. participation in building infrastructure in China. Commerce Secretary William Daley will lead a multi-agency mission to China and Hong Kong, featuring a business contingent of "large, medium, and small firms representing sectors such as . . . information technologies, power generation, oil and gas exploration and downstream development, construction, including residential dwellings, environment, transportation, and engineering and financial services in support of efforts to involve more U.S. companies in China's infrastructure development."

The trip follows up the proposals of the 12th annual meeting of the Sino-U.S. Joint Commission on Commerce and Trade, which was held in Washington on Dec. 17-18, 1998. On Dec. 22, Yu Shuning, Minister-Counselor for Press Affairs from the Chinese Embassy in Washington, presented the results of the Sino-U.S. Commission. Yu stated:

"The Chinese delegation provided the U.S. side with three lists of major projects to provide opportunities for the U.S. business community to compete on the Chinese market.

"The first two lists comprise 28 projects in infrastructure and 10 technical renovation projects, which will be undertaken this year [1998] and in 1999. The amount of these 38 projects is about $20 billion.

". . . [T]he third list comprises 25 sectors, areas for cooperation between the two sides in the period from

1998 through 2005. The value of these projects is estimated at U.S.$600 billion.

"And finally, we told the U.S. side that in this period, from 1998 through 2005, China will import equipment, technologies, and products worth U.S. $1.5 trillion.

"So, there are plenty of opportunities for the U.S. corporations to compete on the Chinese market on a fair basis. We say to address the issue, joint efforts are necessary."

A Ray of Hope

The Daley mission to China, following up on the proposals of the Sino-U.S. Joint Commission, represents a ray of hope that the United States will join the development alliance with China, Russia, and India for the Eurasian Land-Bridge and a real economic recovery based on infrastructure projects. The opportunities are enormous.

The three Chinese lists are broad, and cover an array of hard infrastructure projects. The first two lists alone offer about $20 billion in development projects.

For example, under the category of "Projects Inviting U.S. Companies to Bid," List No. 1 has 28 projects which China has either started in 1998 or will start in 1999, and will likely complete by the end of this year. Among these are eight power projects, including the Qangqu Power Plant in Shanxi Province, the Fuyang Power Plant in Anhui Province, and the Hancheng Power Plant in Shaanxi Province. The list also includes nine projects under the title of "environmental protection," which are plants for clean water provision, sewage treatment, and gas utilization, such as the Zhangjiu River Water Diversion and Supply Project, and urban environment, water supply, drainage, and garbage treatment projects in Chongqing.

List No. 1 also includes three chemical fertilizer plant projects and eight transport projects. The latter includes regional air traffic control centers in Beijing, Shanghai, and Guangzhou, and the Hangzhou-Quzhou Expressway project of the Shanghai-Ruili National Highway.

List No. 2 consists of 10 "technology transformation and renovation projects." These include a project for technological transformation of an electrolyzed copper and aluminum production line with an-

Continued on page 23

CHINESE DEVELOPMENT PROJECTS OFFERED FOR FOREIGN PARTICIPATION

Power Projects:

1. Wangqu Power Plant, Shaanxi Province
2. Fuyang Power Plant, Anhui Province
3. Hancheng Power Plant, Shanxi Province
4. Leiyang Power Plant Phase II, Hunan Province
5. Zhanghewan Pumped Storage Power Plant, Hebei Province (not shown)
6. Tai'an Pumped Storage Power Plant, Shandong Province
7. Zipingpu Key Water Control Project, Sichuan Province
8. Baise Key Water Control Project, Guangxi Province

Environmental protection:

9. Water Supply and Environmental Protection in Tangshan, Shijianzhuang, Handan, and Qinhuangdao, in Hebei Province
10. Urban environment, water supply, drainage, Chongqing, Sichuan Province
11. Five Cities' Construction and Environmental Protection, Sichuan Province
12. Zhangjiu River Water Diversion and Supply Project
13. Fengshouba Water Plant Phase I, Chongqing
14. Sewage Treatment Works, Tianjin
15. No. 10 Water Source Plant, Beijing
16. Town Gas Project, Taiyuan, Shanxi Province
17. Gas Utilization Project, Yangquan, Shanxi Province

Chemical fertilizer:

18. Guizhou Phosphate Ammonia Project
19. Yunnan Phosphate Ammonia Project
20. Hainan Chemical Fertilizer Project (not shown)

Transport:

21. Relocation of Baiyun International Airport in Guangzhou
22. Regional Air Traffic Control Centers in Beijing, Shanghai, and Guangzhou (not shown)
23. Chongqing-Zhanjiang National Expressway
24. Shanghai-Chengdu National Expressway
25. Shanxi Qi County-Linfen Expressway project of Erlianhoate-Hekou National Expressway
26. Beijing-Zhuhai National Highway
27. Nanning-Youyiguan highway project of Hengyang-Kunming National Highway
28. Hangzhou-Quzhou Expressway project of Shanghai-Ruili National Highway

Technology transformation and renovation projects:

29. Improvement of blast furnace, vacuum negative pressure casting production line, Jilin Province
30. Offset printing newspaper, annual output of 170,000 tons, Heilongjiang Province
31. Kraft board and paper, annual output of 170,000 tons, Heilongjiang Province
32. Electrolyzed copper and aluminum production line, annual output of 50,000 tons, Gansu Province
33. High-grade white cardboard production line, Shanxi Province
34. Cycloresin facilities production line, annual output of 20,000 tons, Heilongjiang Province
35. Aluminum alloy high-precision plates system, Heilongjiang Province
36. Cement clicker, daily output of 2,000 tons, Heilongjiang Province
37. Weld steel pipe for boilers production line, annual output of 60,000 tons, Heilongjiang Province
38. Bisphenol A production, annual output of 20,000 tons, Heilongjiang Province

A Call for the No. 2 Bridge To Progress Smoothly

by Xue Jiaji

EDITOR'S NOTE

*The Chinese government sponsored a conference on the Eurasian Land-Bridge, titled "Asia-Europe Economic and Trade Relations in the 21st Century and the Second Eurasian Bridge," which was held in four cities in China Oct. 27-Nov. 1. The conference took a group of foreign delegates—including Helga Zepp-LaRouche, Mary Burdman, and Jonathan Tennenbaum from the Schiller Institute—on a tour of projects in the cities of Beijing, Nanjing, and the sea and rail ports of Lianyungang and Qinhuangdao.**

Both the tour of Land-Bridge development sites, and the speeches of the Chinese officials and economists at the conference impressed participants with China's cultural optimism and determination to develop for the future.

Here we reprint excerpts from the speech of Xue Jiaji, a professor at Jiangsu Provincial Academy of Social Sciences. He spoke at the conference in Nanjing, Jiangsu Province, on Oct. 28. Its full title is "International and Internal Cooperation: A Call for the No. 2 Bridge to Progress Smoothly."

* * *

EIRNS

Jonathan Tennenbaum addresses the Chinese government's Land-Bridge conference in Beijing, in October 1998, on the topic "A Project-oriented Approach to International Economic Relations." Tennenbaum heads the Fusion Energy Foundation in Europe and is a scientific adviser to the Schiller Institute.

The No. 2 Land-Bridge is a silk ribbon connecting Asia and Europe, and an intercontinental chain of international economic cooperation, too. This new type of modern international thoroughfare, which crosses intercontinentally, connects oceans, and is composed mainly of railway transportation, has a system of highway, aviation, sea transportation, river transport, pipeline transportation, and light cable communication, directly by sea and land, from America to Asia, then to Europe, greatly shortens the distance of economic communication of the whole world, and becomes the formal thoroughfare of the whole world's co-development.

Built along the Silk Road, the No. 2 Land-Bridge is shorter by 2,000 km than the Siberia Land-Bridge, and avoids the freezing conditions of high and cold areas. It is a bridge of transportation, commercial, industrial cooperation, and cultural communication. And it compiles a great stream of people, goods, and information. The bridge starts east from the Pacific and attracts the attention of many countries in East Asia, Southeastern Asia, and the Pacific surroundings. From West to Central Asia, West Asia, and Southeastern Asia, and even to Europe, the Land-Bridge becomes the thoroughfare to develop the northern and western areas in China and Central Asia, and strengthens the communication of economy, technology, and culture. From China to Holland, there are 35 countries sharing the fruits of the bridge.

Along the bridge, countries can obviously complement each other mutually and optimize their groupings. Developed countries may march into this super-market, which has a large population and rich materials. Those areas, such as Central Asia and the northwestern part of China and so on, may absorb the foreign capital, technology, and modern management experience to speed up the promotion of economy. It is a trend of social development, to march into the undeveloped places which have wide areas and rich materials, and create a new wide area for human living, prosperity, and development. Although there is a beginning of a "knowledge economy," it does not mean the end of agricultural and industrial economy, but to improve the traditional industries to a higher level. It does not mean the end of resource exploitation either, but to rationally develop and make effective use of resources.

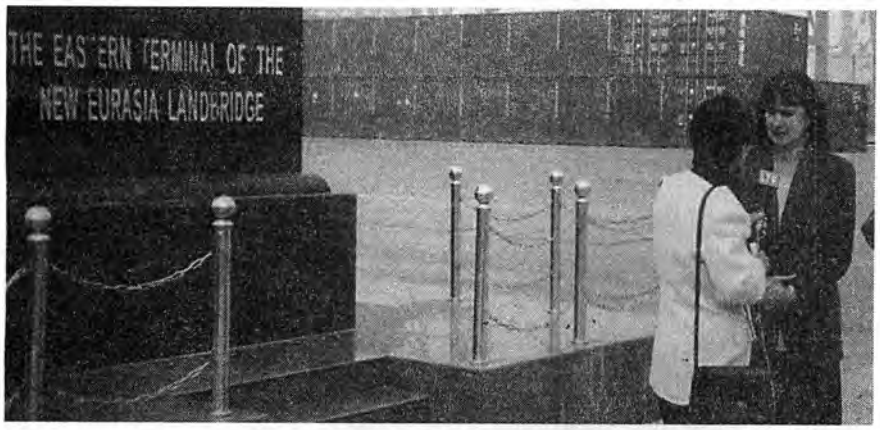
Resource Development

Especially in the huge undeveloped areas, resource development and industrialization are still the most important

tasks. The construction of the Land-Bridge offers more convenient conditions for further prosperity and development than before.

The No. 2 Land-Bridge is an intercontinental chain, and an inner gold belt for coordination of the east, middle, and west parts of China. It is an important lever for the international and internal cooperation in order to make the bridge ply smoothly.

1. *International cooperation.* . . . One lagging factor for the development of the bridge is that the transit tariffs are different between countries, the rates remain unstable and there are many taxes and incidental expenses. This raises the transportation cost. Additionally, the competition between the old and the new Land-



EIRNS

Helga Zepp-LaRouche speaks with reporters at the the eastern terminal of the Land-Bridge in Lianyungang, in October 1998. She headed the Schiller Institute delegation attending the Land-Bridge conference sponsored by the Chinese government and held in four cities.

The LaRouche Economic Method and the Land-Bridge

by Helga Zepp-LaRouche

This is an excerpt from the speech of Helga Zepp-LaRouche, president of the Schiller Institute, at the opening session of the international conference on the Land-Bridge in Beijing, Oct. 27. Her presentation was titled "Principles of Foreign Policy in the Coming Era of the New Eurasian Land-Bridge."

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In modern times, it has been the American economist Lyndon LaRouche who developed a scientific measurement for the intelligibility of the common good, and for what are the necessary criteria for development. Over the long term, that yardstick for a successful society, is LaRouche's notion of relative potential population density. . . .

The increase of the actual and potential population-density over the last millennia, to presently circa five and a half billion people in the world, is the result of the continuous production, distribution, and effective absorption of scientific and technological progress.

The transformation of productivity per square kilometer and per capita, reflects itself in the following qualitative changes:

(1) The efficiency of each square kilometer, for the purpose of production and human settlement, must increase.

(2) The productivity of labor in the process of production must increase.

(3) The material living standard per capita and household in terms of a market basket, must increase.

If these parameters are followed, we realize that the average square unit of territory required to maintain a person, is being reduced, while at the same time, the required material consumption increases.

In the case of continuous physical productivity of labor and the related increase in the per capita consumption, the following tendencies occur:

(4) The energy throughput per square kilometer and per capita must increase.

(5) The efficiency per square unit in the production process must tend to increase.

With these improvements in physical economy, there is also a change in the social characteristics:

(6) The relation of the urban to the rural population increases until it apparently asymptotically reaches an upper level.

(7) The ratio of those employed in the production of capital goods increases, as compared to those producing for household consumption and related goods.

These changes occur in such a way, that the production of agricultural and household goods for consumption never decreases, but increases per square kilometer and per capita. Under these conditions the following demographic changes will result:

(8) The age of the maturity of the individual before entering the workforce increases.

(9) There is a shift away from labor-intensive, toward energy-intensive types of employment.

All these preconditions must be fulfilled and maximized at the same time. Together, they illustrate the connection between technological progress and the increase in the potential population density. Even among countries with different levels of development, they give a guideline for the direction in which society should go.

For obvious reasons, the New Eurasian Land-Bridge, as the cornerstone for a global reconstruction of the world economy, emphatically including Africa and Ibero-America, must be the concrete framework for the principles mentioned above. All participating sovereign nations should not only agree that building the Land-Bridge is their common interest. In addition, these nations should also agree that the application of the principles mentioned above, is not only in their own best interest, but it is also in their own best interests that all other sovereign nations also apply them. In this case, peaceful cooperation for each others' mutual benefit is guaranteed.

Bridge obstructs the new bridge. In fact, each of the two land-bridges has its advantages. With the development of international trade, both of them will give play to their particular function.

2. *Internal coordination of transportation and services along the bridge.* The whole bridge is 10,900 km long; 4,131 km are in China, and 37.9 percent of the whole length runs across the middle, east, and west of China, including 10 provinces: Jiangsu, Shandong, Anhui, Henan, Shanxi, Gansu, Ningxia, Qinghai, and Xinjiang. To build the bridge, we must build good relations among the 10 provinces in China. We must break down the phase in which each does things in his own way. . . .

3. *Commercial coordination and development of the information network between areas.* The operation of the bridge will impel the development of the overall circulation and commercial trade. Especially the central cities along the bridge must fit this kind of situation, trading with each other closely and forming a market network along the bridge. . . .

4. *Coordinate development of the east, middle, and west. . . .*

[T]he main development approach is to cultivate growing points with the help of big and medium-sized cities along the bridge. . . .

5. *Cooperation in resource development.* Along the line of the bridge, the large area with rich resources is a relatively backward, huge space for development. . . .

6. *Special opening-up measures.* At present, the opening along the bridge is at too low a level, and the ability to attract investment is weak, too. So opening-up should have special measures, which include the establishment of a low-tax area or belt. . . .

The economic foundation in many areas along the bridge falls short, the economic strength is not great, and there are many desolate areas where nature resources are also poor, and the need of investment is large. If we do not take special measures for opening-up, it will affect the development and progress of the bridge area.

Notes

* For a full report on the conference, including the speeches presented by Helga Zepp-LaRouche, Jonathan Tennenbaum, and several Chinese officials, see *Executive Intelligence Review*, Dec. 4 and Dec. 11, 1998.

Chinese Infrastructure Projects

Continued from page 20

nual output of 50,000 tons in Gansu Province, and a cycloresin facilities production line with annual output of 20,000 tons, in Heilongjiang Province.

The third list is composed of 25 projects that will be constructed in China between 1998 and the year 2005. It consists of everything from a 600-megawatt supercritical and cooling thermal power generator, to technology for shallow-sea oil drilling and exploitation. These projects have a combined value of $600 billion.

Finally, as Minister-Counselor Yu indicated, between 1998 and the year 2005, the Chinese will need to purchase $1.5 trillion in capital goods such as machine tools, and other technology, to build the infrastructure projects listed, as well as others that the Chinese are working on.

U.S. companies will have to bid on these projects, along with companies from other countries, but still there is an enormous amount of business to go around.

Solving the U.S. Trade Deficit

The meeting of the Sino-U.S. Joint Commission, and the lists, represent a very good way to deal with the growing U.S. trade deficit with China. In 1990, the U.S. trade deficit with China was $10.4 billion; in 1998, the Commerce Department estimates, it was $58 billion. Moreover, for the first 10 months of 1998, Chinese exports to the United States, at $59.5 billion, were five times the size of U.S. exports to China, at $11.6 billion.

At his Dec. 22 press conference, Minister-Counselor Yu responded to a question about U.S. government restrictions and controls on the shipment of certain categories of U.S. high-technology exports to China, by calling for a "loosening of the U.S. controls." High-technology products are "the strong point for the U.S. economy," he said.

U.S. Representative Christopher Cox (R-Calif.) and the House Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China, which he chairs, together with other "neoconservative outlets," are trying to stop any high-technology trade. However, not only are their fears completely unwarranted, but they are pushing the U.S. economy in exactly the wrong direction. The Chinese are deliberately trying to arrange for the United States to ship a large volume of high-technology goods, like transmission lines, advanced machine tools, and infrastructure-related and other goods to China, for use in its industrialization process. Through such state-to-state intervention, the Chinese are trying to defuse the trade issue by reducing the Chinese trade surplus with the United States in a rational manner.

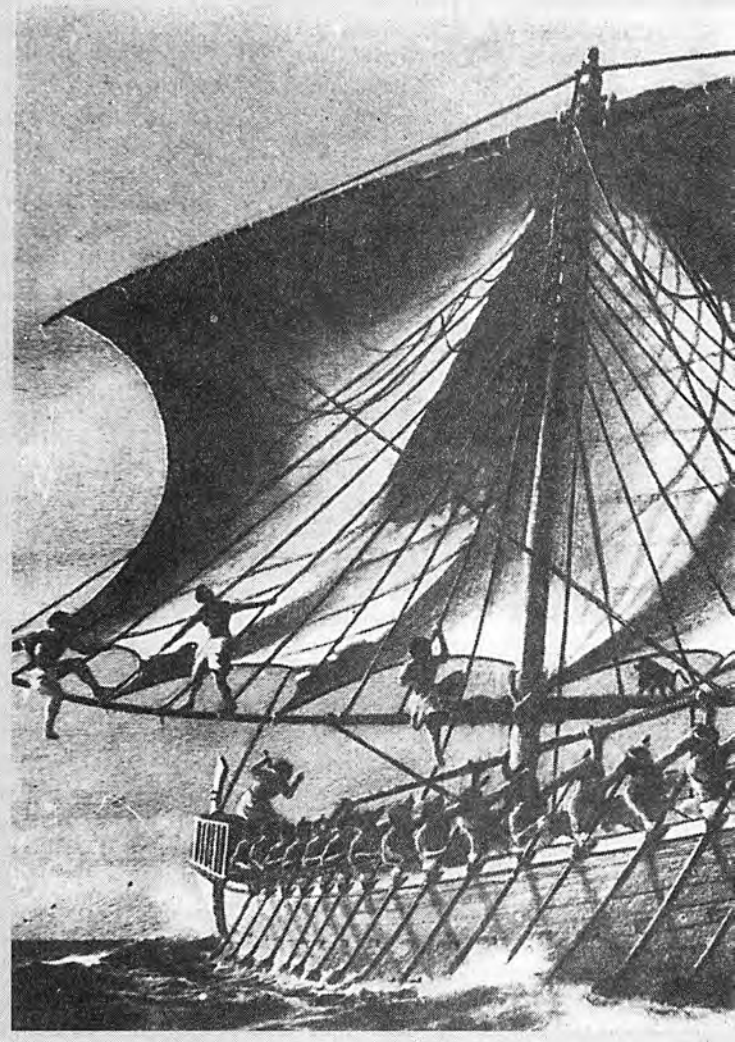
Such infrastructure and related trade projects in China could add $100 to $200 billion of high-technology physical goods to the order books of failing U.S. manufacturing companies over the next 10 years, and provide employment for tens of thousands of manufacturing workers.

Cabinet and senior officials in Washington who are involved in infrastructure will participate in the mission. They will visit infrastructure sites and meet with Chinese ministries responsible for building infrastructure. In addition, as part of the trip, according to a Commerce Department briefing paper, Daley will go to Hong Kong, where "he will . . . urge selection of U.S. firms for Hong Kong's infrastructure efforts with $30 billion in projects to be developed over the next five years."

The United States has posted a full-time U.S. trade finance officer connected with the U.S. Export-Import Bank, in Beijing, and the United States plans to have an Ex-Im representative in Shanghai soon. This will upgrade the U.S. commercial presence in China substantially, as well as provide U.S. companies with an interface with the Chinese government. According to an Oct. 2, 1998, Ex-Im Bank press release, China is now the bank's largest market, surpassing Mexico for the first time, with an Ex-Im Bank exposure of $5.8 billion. This represents nearly one-third of all Ex-Im Bank exposure worldwide.

Richard Freeman is an economics writer for the news weekly Executive Intelligence Review. *His full report on this topic appeared in the Jan. 29, 1999 issue of EIR.*

On Eratosthenes, Maui's Voyage of Discovery, And Reviving the Principle of Discovery Today



by Lyndon H. LaRouche, Jr.

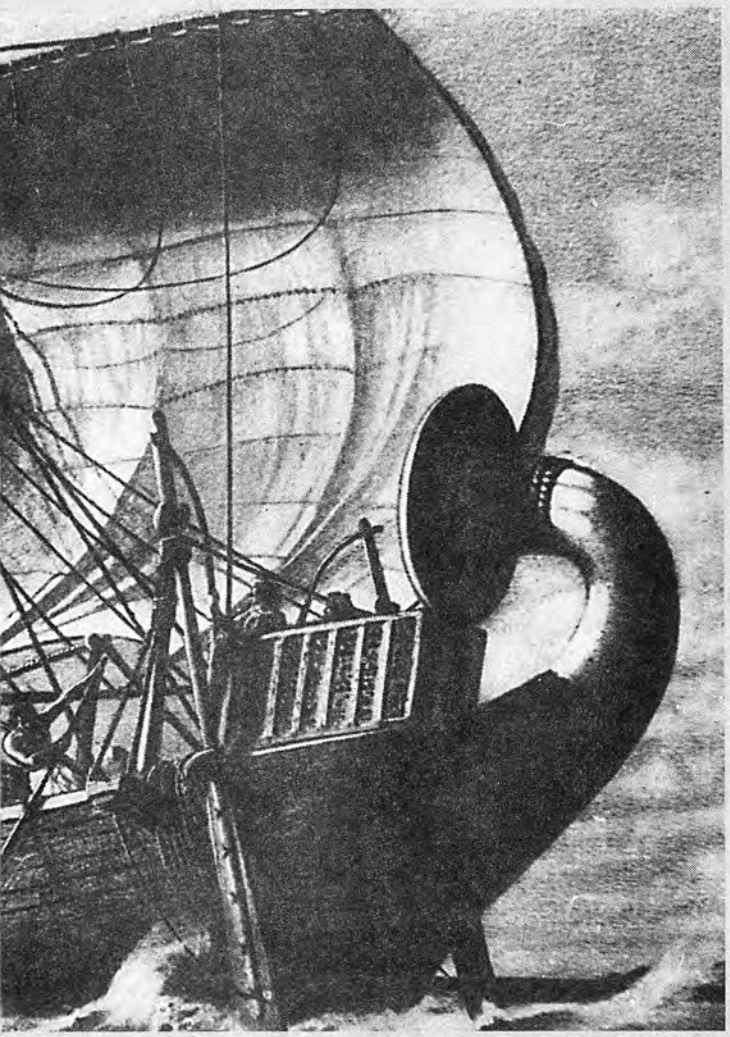
How man's mind functions to improve our power over the universe, by means of which we exist and develop.

EDITOR'S NOTE

This article is adapted from a transcription of a presentation made by LaRouche at the winter conference of the Schiller Institute and International Caucus of Labor Committees in Bad Schwalbach, Germany, Nov. 21-22, 1998. LaRouche's speech keynoted a panel he commissioned, "What Is Real History As Science?" The panel included Gabriele Liebig on "Homer's Odyssey, Long-distance Seafaring, and the Principle of Colonization," (this issue, p. 36), and Muriel Mirak-Weissbach on "Wilhelm von Humboldt's Study of the Kawi Language."

LaRouche was introduced by Dr. Jonathan Tennenbaum, head of the Fusion Energy Foundation in Europe and scientific adviser to the Schiller Institute. Tennenbaum has been studying the history, language, and culture of China, and in his introduction, he told this Chinese story, which dates back 2,000 years:

"There was an artist who painted on a big wall four beautiful dragons. But people who saw this painting of the beautiful



Corbis-Bettmann

An Egyptian ship around 1500 B.C., as drawn from a relief in the temple of El Bachri.

dragons on the wall, noticed that there were no eyes on the dragons. They were otherwise very powerful and very impressive, but had no eyes.

"So, people asked the artist, 'Why don't you paint the eyes on the dragons?' And the artist said 'Oh, no, no, no. I can't do that. If I would paint the eyes on the dragons, they would fly away.'

"Well, people didn't believe him, and finally, under a great deal of pressure, the artist agreed to paint the eyes on just one of the dragons. As soon as he put the eyes on the dragon, there was a great storm of lightning and wind, and suddenly, the dragon that had the eyes painted on, started to move, and flew up to the heavens. And the dragons that didn't have eyes, stayed on the wall, where they were painted.

"That's the story. Now, how is this used as a metaphor? It's used very commonly in China, to refer to the following situation: If you are writing an article, or giving a speech, there are sometimes certain things which, if they are added—they might be very small—but if they are added, they cause the article or the speech, or the painting, to suddenly become extremely powerful, more powerful than it would be if this element was not added.

"So, this is called 'adding the eyes to the dragon.' And in accordance with that, I would say, in Chinese style, that our conference, up to now, is really a very powerful dragon. We've had powerful speeches, very important things to say. But I think perhaps in this panel, something very special will be added, that will cause the dragon of our conference to fly up to heaven, and to become even more powerful than it was up to now.

"So, with that, I want to introduce Lyndon LaRouche, who will bring us to our main topic."

The argument essentially is this: Sometimes, in the course of history or scientific investigation, one is presented with a very fascinating and very challenging pattern of evidence. But, it's not yet conclusive. It teases you, it tempts you, it draws you into the subject matter. But you cannot finally draw a conclusion which settles the argument. It's something like a dog lurking in your backyard: It's just there all the time. You don't know to whom it belongs, you just know it's there. And you wait one day for its master to come by and claim it, or something else to happen, so that you may identify to whom this dog belongs.

Such is the nature of the matter we're dealing with today.

We'll start with the overall map, and we'll refer to this repeatedly (Figure 1). Now, the subject, the apparent subject, which is extremely tempting, and is especially tempting because there is an "eye" in this right away, in Jonathan's sense, to begin with, is that a group of mariners under Egyptian direction, from an area then of Egypt, now of Libya, called Cyrenaica, set sail in a flotilla of ships which went down the Nile River and out to the Red Sea through a famous canal, which at that time connected the Nile River to the Red Sea.[1]

These people then sailed—this was in 232 B.C.—they sailed to a place known to them, which is in the area today of Indonesia, which we'll refer to again. There, Maui, the chief mariner, the navigator of the expedition, recorded a comment, which is a well-known comment, and recorded also an eclipse, which is a well-known eclipse, and gave the dating for that observation in a report which was painted in a cave, which they went to commonly.

Now, these Egyptian ships, on this occasion, were very large ships. They were not jokes. They were not balsa rafts. They were very serious ships, and I'll come to that in a while.

From thence, from inference, we know the expedition continued its journey from this West Irian location, across the Pacific Ocean, to probably about Panama. And I'll tell you why later. It then explored the South American coast, trying to find

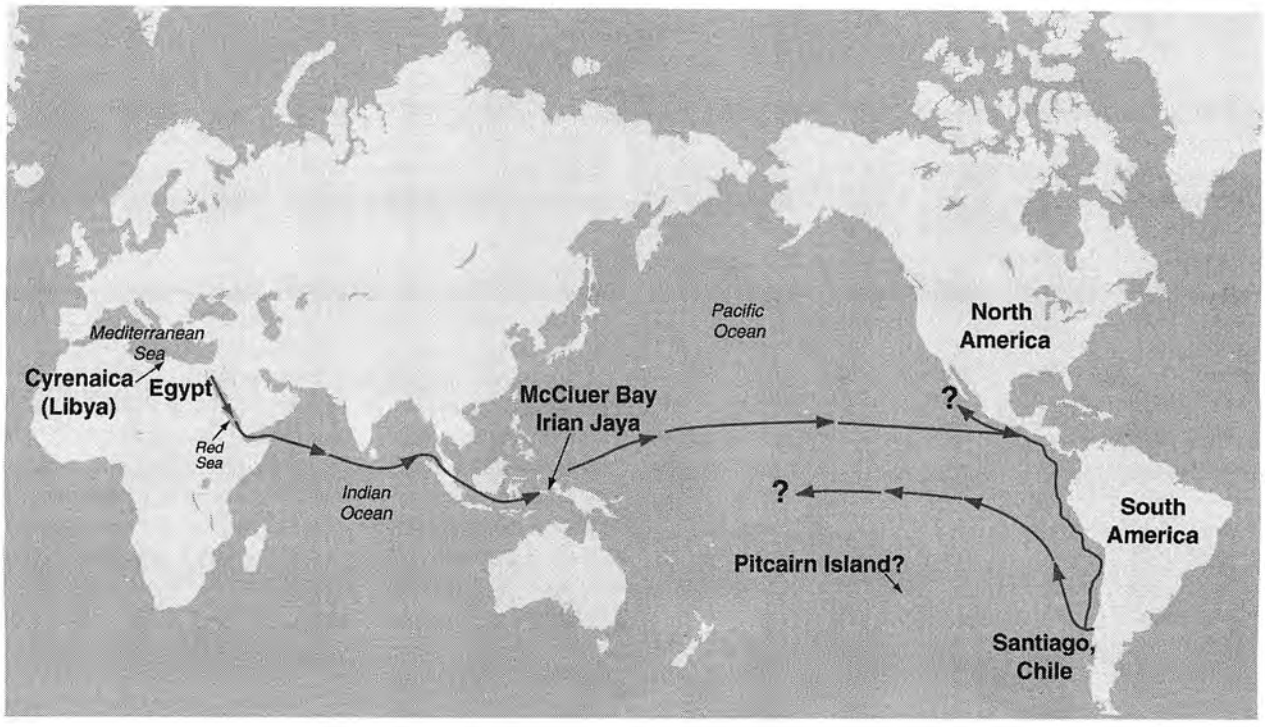


Figure 1
PROBABLE ROUTE OF THE EGYPTIAN VOYAGE IN 232 B.C.

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

a way through the Americas, into the Atlantic Ocean, so they could get back to Egypt by way of the Atlantic.

The Egyptians Got There First

Finally, after completing the exploration of the coast of South America, on Aug. 5, 231 B.C., the chief navigator of the expedition, Maui, went into a cave area outside of what today is Santiago, Chile, and there made a record of their arrival, of their exploration, and claimed all of South America for Egypt.[2] So you see there are some Spanish land-titles that aren't too good these days.

The expedition attempted to return, but never returned to Egypt, because of a shipwreck, including one which occurred, according to record, on Pitcairn Island, which is the island known for the sailors who escaped from the *H.M.S. Bounty,* in the famous "Mutiny on the Bounty." And they left a record of their arrival and shipwreck on Pitcairn Island there.[3] The remainder of the expedition stayed in the Pacific, among people whose language they spoke, people we call today "Polynesians." And they taught the Polynesians the art of transoceanic navigation.

The next time an expedition of this type is known to have occurred, was 1,723 years later, a little bit more than that, when Columbus, in October of 1492, reached the Caribbean in a transatlantic voyage.

Now, Columbus's transatlantic voyage, was based on a map, a map prepared for Columbus, by a man who had entrusted a copy of the map to his friend in Portugal (Figure 2). Columbus then corresponded with the author of the map, Paolo dal Pozzo Toscanelli, and got further advice from him on how to navigate across the Atlantic, to discover the land on the other side of the Atlantic Ocean.

Now, there are several crucial things, to talk about Jonathan's "eyes on the dragon," in this. There are several "eyes."

First of all, there was no civilization capable of making that kind of science-directed, transoceanic expedition, between 232 B.C. from Egypt, and Columbus from Europe.

What does that tell you about the history of European civilization between the time of Maui, who was the navigator for this expedition, and the European civilization, which finally came out of the mud to be able to make a *deliberate* transatlantic exploratory voyage?

What we're talking about, is essentially a collapse of civilization which dates from about the time that the Latins, the Romans, murdered Archimedes, until the Renaissance. Because it was the circles of Nicholas of Cusa and his friends, including Paolo Toscanelli, who made possible the discovery and use of the knowledge which instructed Columbus on how to navigate to find land on the other side of the Atlantic.

In between those times, all European civilization was inferior, in its scientific and cultural development, to Egyptian civilization of the time of Archimedes and his friend, Eratosthenes. That is the "eyes on the dragon."

That tells you that the idea about culture and civilization, which is popularized in European and other histories since then, is a gigantic fraud, a deliberate fraud. One of the examples of the fraud is the case several centuries later, five centuries later, when a hoaxster by the name of Claudius Ptolemy, faked evidence—absolutely faked it—using known evidence from a period of about 500 years earlier, and faked the evidence to try to show that the Earth was the center of the Universe, that the Sun orbited the Earth, not the Earth the Sun.

Whereas five centuries earlier, *all civilized science knew, and had measured the fact, that the Earth was a sphere, or a spheroid, and had made measurements pertaining to the distance of the Earth from the Moon, and estimates—not very good ones, but estimates, nonetheless—of the distance from the Earth to the Sun, around which the Earth orbited.*

The central figure of this, was the scientist Eratosthenes. Now, just to put this historical point into focus, look at the map of the Mediterranean region (Figure 3). What I want to point to, in particular, is the region called Cyrenaica and the approximate place on the Nile where the canal cuts to the Red Sea.

Peoples of the Sea

Go back a bit in European history. The people who lived in Cyrenaica, were famous navigators. The reason they were famous navigators, is that they belong to a group of people who were called at that time, the Peoples of the Sea. These were people who, from before the second millennium B.C., were accustomed to using sailing ships, which looked very much like what we call Viking ships: single sail, able to tack into the wind, somewhat like the ships of Henry the Navigator later. And they were all over the ocean, all over the world. They were in the area of the North Sea, long before the Vikings.

Remember, the Vikings were not really a people. They were Saxon bandits who fled from Charlemagne, when Charlemagne invaded this area of Saxony. And this bunch of heathen, who were controlled from Constantinople, revolted. And when Charlemagne defeated them, they fled north into the area around Jutland. There they became known as Vikings. They were mixed, a lot of different kinds of people. They had one common denominator: They were all juvenile delinquents—robbing, stealing, raping, doing all these kinds of things that the British oligarchy does today.

But a long time before then, you had an extended civilization, which was Atlantic. And the people of this Atlantic civilization came down in their ships. And as the glaciation retreated, they came more and more into the Mediterranean, and they came down also by the river system, which is essentially the sys-

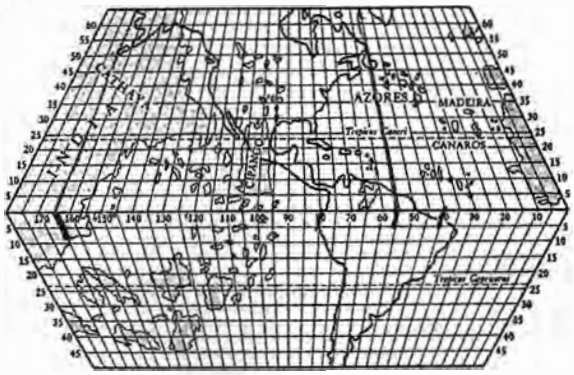


Figure 2
TOSCANELLI'S MAP, USED BY COLUMBUS ON HIS FIRST VOYAGE

"There was a collapse of civilization from about the time that the Romans murdered Archimedes, until the Renaissance. It was the circles of Nicholas of Cusa and his friends, including Toscanelli, who made possible the discovery and use of the knowledge which instructed Columbus on how to navigate to find land on the other side of the Atlantic."

Here, Toscanelli's map, used by Columbus, on which is superimposed an outline of North and South America.

Source: arttoday.com

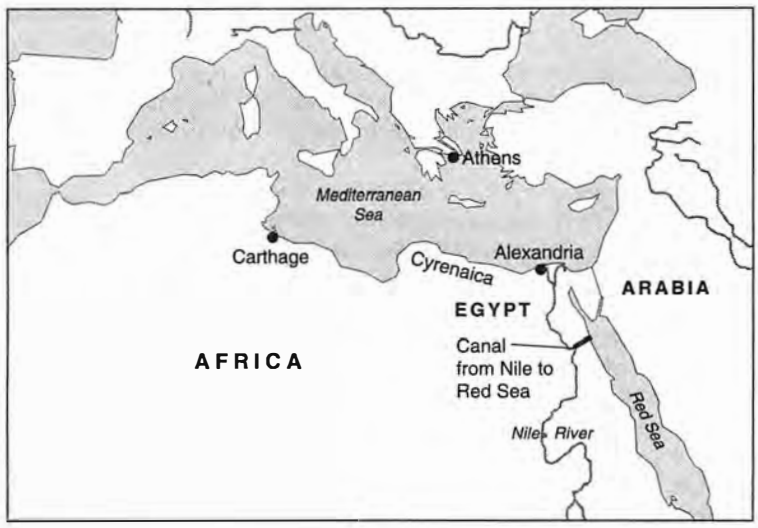


Figure 3
THE MEDITERRANEAN REGION

"The entire history of European civilization emerges in this cockpit, which points of reference are Egypt, Ionia, Athens, and the Etruscans, and developments in southern Italy. . . ."

The Egyptians built a canal from the Nile to the Red Sea, and carried out extensive, long-distance maritime trading and mining expeditions to the east, including to China. The Cyrenaicans, who were known for their skill as navigators, were allies of the Egyptians, and were the link between Greece (Ionia) and Egypt.

arttoday.com

A 19th century illustration of Christopher Columbus with Toscanelli's map.

tem of the Danube, the Rhine-Danube connection, from the north into the Black Sea, and down. And they became known—some of them became known later as Greeks—as "Peoples of the Sea."

In the 2nd millennium B.C., you find sites, megalithic sites, in which the walls of the city are to the inland, not to the ocean, because the Peoples of the Sea had to protect themselves against marauders or barbarians *from the inland.* They were the Peoples of the Sea, the sea-raiders.

Now, in this process, a differentiation occurred. And this began in the 2nd millennium or earlier B.C., when the Egyptians proceeded to try to civilize these Peoples of the Sea. And the Egyptians picked out an area here, a settlement of Peoples of the Sea, in Cyrenaica, which became, on and off thereafter, closely associated with Egypt. And Cyrenaica was, for Egypt, also associated with Ionia, which became the Ionian Greeks, and with the Etruscans and others.

The Etruscans were the allies of Egypt and the Cyrenaicans, against the Carthaginians, that is, against the Phoenicians in the western Mediterranean; whereas the Ionian Greeks, together with Athens, which is one of the cities related to it, were the allies of Egypt against the Phoenicians, against the Canaanites.

So, in this period, Cyrenaica plays a key part as essentially the link between Greece and the Etruscans, and Egypt, during the entire period. So, with all the dark ages and fluctuations, and so forth, back and forth, there's this Mediterranean culture.

So, when you're talking about Greek culture, or Etruscan culture, which we know less about, because the Romans, the Latins, committed genocide against the Etruscans, to try to wipe out and eradicate every evidence of Etruscan culture, as they tried to pretend that Italian is a language descended from Latin, which it is not. It's a completely separate and superior language to Latin, which is something that the Humboldts understood. And they got into trouble at the time when Wilhelm von Humboldt was the ambassador to Rome, over making the point, the obvious philological point, that Italian was a separate language which had cohabited with Latin, and therefore had a lot of cross loan-word relationships, but that the Italian was a separate culture, probably a superior one, to the Latin culture of the Romans.

The Center of Civilization

You had also in there, of course, the Magna Graecia culture, much of which was very closely associated, again with Ionia, and with Athens, and with other centers. So the entire history of civilization, of European civilization, emerges in this cockpit, which points of reference are Egypt, Ionia, Athens, and the Etruscans, and developments in southern Italy—Sicily—which came out of this process. That's the center of civilization.

From the beginning of the Homeric legends, or the Homeric epics—which probably are to a large degree true, as Heinrich Schliemann and others have demonstrated—from this period, there emerged, earlier than the middle of the 1st millennium B.C., there emerged a great Greek culture, typified by the greatest works of the Ionians, such as Thales and Heraclitus, or Solon of Athens, who is part of the same process. Very closely associated with certain forces in Egypt, and always associated with Cyrenaica.

For example, when Plato formed and developed the Academy at Athens, one of the more important mathematicians was

From the British Museum in London, as reproduced in *City of the Stargazers* by Kenneth Heuer (New York: Charles Scribner's Sons, 1972), p. 41.

Ptolemy III, the Egyptian king at the time of Eratosthenes and the voyage of Maui and Rata, as depicted on a gold coin of Alexandria, after the king's death. The trident of the sea god Poseidon is at his shoulder.

Theaetetus, who was from Cyrenaica. He was the person who first developed the concept of the five Platonic solids, a very crucial part of the whole picture.

Then, the case of Eratosthenes. Eratosthenes comes much later. He comes in the 3rd century B.C. He was born in Cyrenaica. He travelled to Athens, where he was educated by Plato's Academy. He became particularly celebrated as the greatest mathematician of the Academy at that time. He was then invited to Egypt to educate the future Pharaoh. He succeeded very well there, and in the course of time, became the librarian of the Library of Alexandria, and a very powerful, politically powerful individual in the Egyptian history of that period.

He was also the greatest scientific mind of the entire period. He was a correspondent, an ally of Archimedes, though they had differences on certain things. And he was far greater in the profundity of his crucial discoveries, than Archimedes. But Archimedes was one of his pals, shall we say.

Eratosthenes was the first to demonstrate rigorously, a method for measuring the circumference of the Earth. He was the one who developed and perfected methods for ocean navigation, using the ecliptic as a constant reference for navigators, which shows up in this.

And thus, when the navigator Maui, under Captain Rata, set forth with a flotilla from Egypt, *on the instruction of Eratosthenes—and Maui left records to this effect (see Figure 4)—to explore the circumference of the Earth,* they successfully, with a series of steps, went eastward. Then they came into an unexpected object: the Americas. They couldn't get through it. According to the record, they explored about 4,000 miles of the coast of the Americas, chiefly South America, probably as far north as Baja California. Some records seem to indicate that

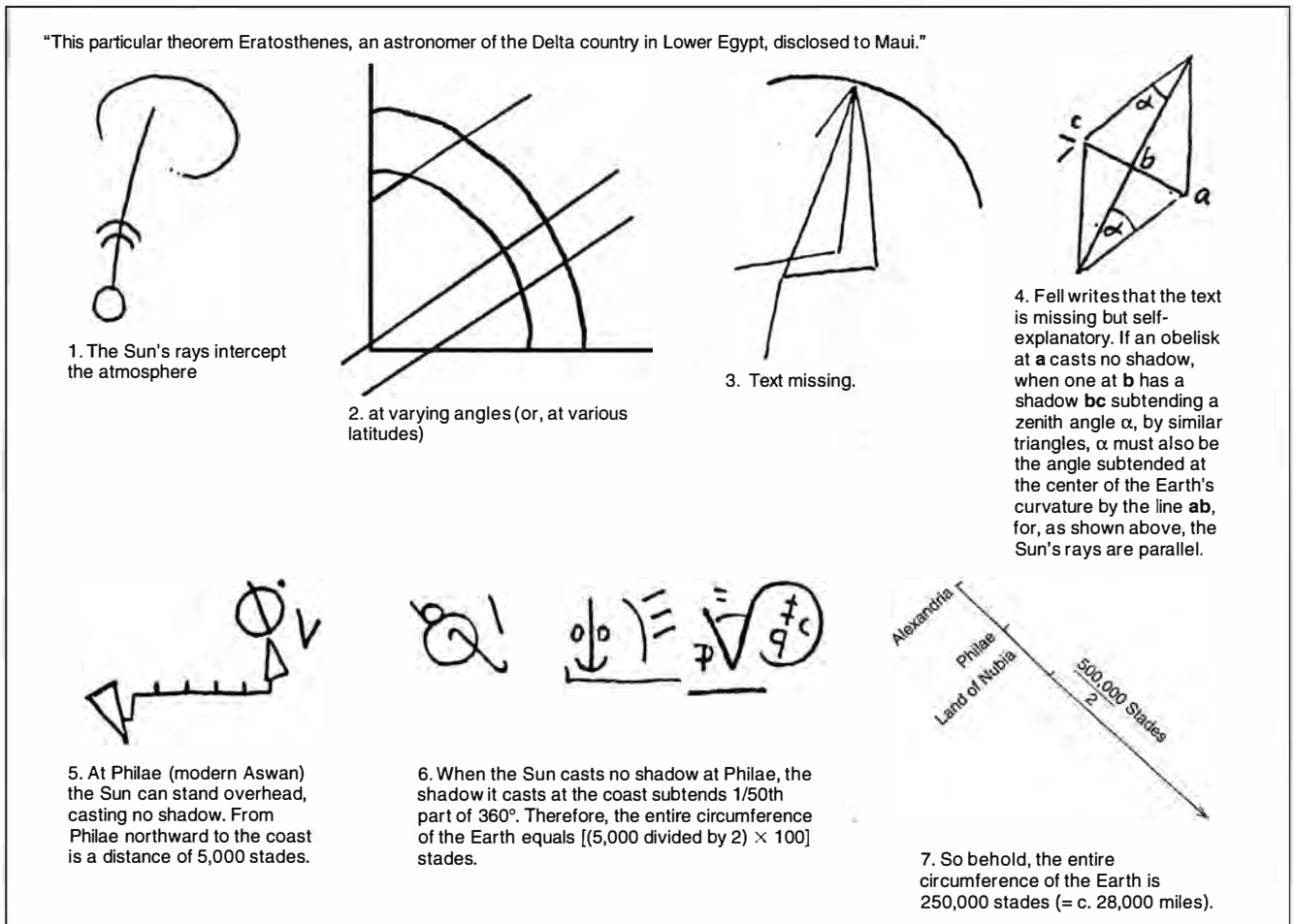


Figure 4
MAUI'S PROOF OF ERATOSTHENES' MEASUREMENT OF THE SIZE OF THE EARTH, AS TRANSLATED BY BARRY FELL

Egyptian inscriptions on the walls of the Caves of the Navigators, discovered by German ethnologist Josef Röder in 1937 in Irian Jaya, the western part of New Guinea, were photographed and later published, but not deciphered at the time. Barry Fell translated them in 1974. These are Fell's drawings and translations of one section of the inscriptions, which gives Maui's proof of Eratosthenes' measurement of the size of the Earth. Another form of the proof is shown in Figure 5.

The graphics and text are reproduced here, with permission, from the Epigraphic Society Occasional Publications, *Vol. 1, No. 18, Nov. 13, 1974. For information on the Epigraphic Society, see note 3, p. 35.*

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Metaphor in stone: "The great tradition of civilization, comes from people like Thales, Heraclitus, the Homeric epics; from the Great Age of Pericles. You see it emblazoned in stone, in the Athens of Pericles, in the methods of sculpture of Scopas and Praxiteles, in which the triangle, four-square conception of art was replaced . . . by imbalance, where the imbalance created metaphor." Here, Praxiteles' sculpture of Hermes with the infant Dionysius.

some of the Arizona and related relics, were copies of records that had been made earlier in some nearby vicinity, which is probably Baja California.

So, this particular part of Mediterranean culture is the cockpit of modern civilization, for reasons I've given otherwise earlier. Then the story becomes even more interesting.

Language and Man's Existence As Man

Over a period of time, these records took some deciphering by ethnographers, who later, in about the 1970s, began to discover how to translate these rebuses into actual messages. This was discovering what language was being used. And in the 1970s, middle 1970s, various groups of people, centered around a fellow called Barry Fell, at Harvard University, in studying these matters, came to the discovery that this language was a language common to the Cyrenaicans, and also common to the Polynesians, with affinities with other languages of that Pacific region, such as the Malay language. And also traces of Dravidian and other kinds of things in there.

So, they recognized that this language, Maori, was the same language which is used by the Cyrenaicans. They had a common language. "Wait a minute!"

Now, let's get back to the Pacific map (Figure 1). Now, what are we saying here? We're saying, as we'll address later in the course of today, that mankind did not plop on this planet—God did not stand in Mesopotamia in 4004 B.C., and create the universe. That didn't happen. The universe is very old, and man is very old. The existence of man on this planet, is probably somewhere between a million and two million years, maybe longer.

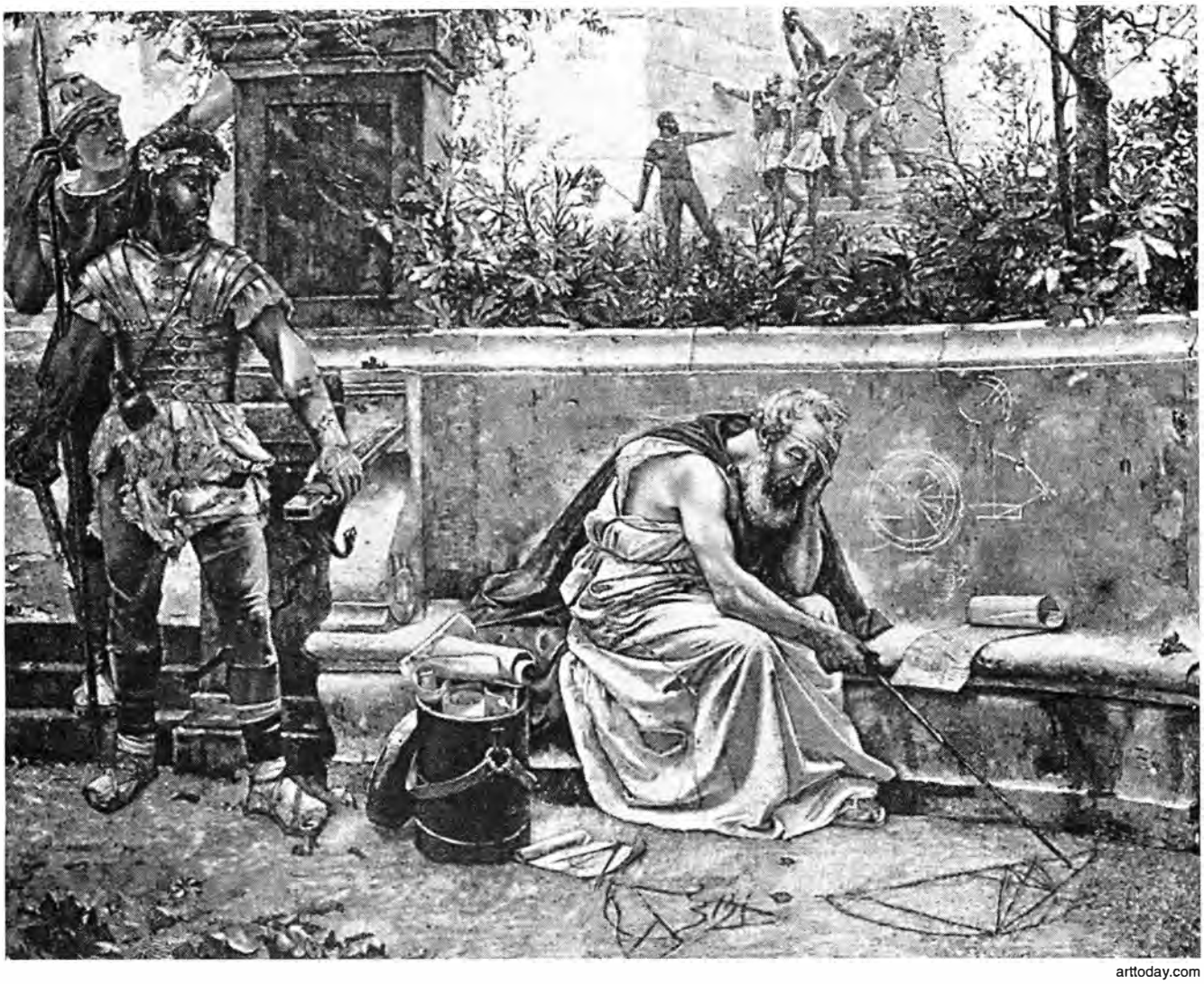
Now, how do we recognize man? We recently had in Germany, out of a group working out of Göttingen University, a discovery of a site of throwing spears in a deep cave in the mountains, here in Germany, a site dated from about 600,000 B.C., in which the design of throwing spears, the well-balanced design of throwing spears, shows what? It shows something that no animal could do, no animal mind could do.

It shows that you had a very advanced form of human cognition, demonstrated by artifacts from 600,000 B.C. And obviously, this is a pretty far advanced part of man by 600,000 B.C. So, we have to go back somewhat earlier—don't we?—to find man. And it's difficult, because the pattern of glaciation on this planet, affecting the Northern Hemisphere, goes back about 2 million years, on the basis of core samples that have been taken in various parts of the world.

So, we're really in kind of poor shape, at this point, for going much earlier. But man's existence on this planet as man—a genotype with specific cognitive characteristics, which do not exist in an animal, only exist with man—existed, fully developed as potential, a million or more years ago.

Well, what do we know of history? The best indications we have of history today, enabled us to scratch back to about 10,000 to 12,000 years ago. What happened to man all this time? It was in this time, before "history," that the basic structure of the great language groups emerged.

For example, you have a language, like a Dravidian group, which is associated with the Indian Ocean and Pacific, which is a dominant culture in that region, until the Aryan migrations from the polar region and Central Asia, down into India, where you've got chiefly the modern culture of the subcontinent,



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Archimedes (c. 287-212 B.C.), depicted here as he is about to be murdered by a Roman soldier, who steals up on the geometer while he is engrossed in working through a problem.

based on an interaction between a Vedic Sanskrit language group, and a Dravidian group, in terms of culture.

Look at Southeast Asia: You've got implications of Dravidian types of languages, crossing with Chinese languages from South China. Thai, for example. Thai has a structure which has predominantly Chinese origin. It has also strong Dravidian influences and cultural influences. And it also has a strong Aryan cultural superimposition, on a basic Chinese language structure.

So you have the Dravidian language, the China-related language group. Then you have the Malayan-related group, which includes the Polynesians. These cultures. Then you had the great polar group that we know of, which is the group from which the Aryan so-called group comes. We have another group, which we don't have much on (we have relics of it), which is a transatlantic group, which almost went out of existence, because it degenerated into the form in which the Europeans discovered the indigenous cultures of Central and South America later on. Probably from between 1000 B.C. and 1000 A.D., there was a great collapse of the quality of culture in what we now call the Americas, so that most of the so-called indigenous cultures of the Americas, were greatly degenerated cultures, which had come from a much higher level of culture, which had degenerated much earlier.

Transoceanic Maritime Cultures

So then, you look at the history of mankind. You say there are certain groups of languages, which define the dominant cultural strain of humanity, strains which originate during the period of the last 100,000 years or so of the Ice Age, or earlier. These languages are what? These languages are largely transoceanic maritime culture languages. They come from a period when the level of the oceans was between 300 and 400 feet lower than today, when a great amount of the oceanic water was sitting on top of the Northern Hemisphere, in the form of great glaciation. In that period, the sea-levels were much lower, and the coastal areas were much lower. And you had great maritime cultures, including those which inhabited the Arctic region, which was more habitable than Northern Eurasia, during the time of the great glaciation.

"The Well of Eratosthenes," by Howard Payn in *The Observatory*, Vol. 37 (London: Taylor & Francis, 1914), as reproduced in *City of the Stargazers* by Kenneth Heuer (New York: Charles Scribner's Sons, 1972), p. 89.

The well of Eratosthenes. A photograph taken in 1914 of the well ascribed to Eratosthenes, located on the Island of Elephantine at Aswan on the Nile. The well is 25 feet deep, with spiral steps leading down to the water. The upper part of the stonework is modern, but the stones below are ancient.

Maritime cultures. You have the traces in the spread of foodstuffs from primitive seeds and primitive stocks, which were brought together from many parts of the world, in the same way that the food cultures, like tomatoes and potatoes and so forth, from South America, were brought into Europe. You had an oceanic movement of foodstuffs through these great cultures.

And then, in relatively modern times, in historic times, these great maritime cultures, produce so-called riparian cultures. In other words, man's culture did not come from inland, down the rivers to the oceans. What we know of man's culture, from the standpoint of languages is that the great language groups came from maritime oceanic cultures, which are the great communicators of ideas and technologies.

These cultures, as they developed in a maritime environment, created the basis for the up-river culture. Of course, our great people from Hamburg would insist that the cultures of the inland of the Elba and Rhine, were developed by the Hansa. But, something like that did occur.

You have, for example, Mesopotamia, which in the 5th and 4th millennium B.C., was an area that was beginning to dry out, inhabited by Semites who were very ignorant, very brutish, no culture, no civilization to speak of. And along came some Dravidians, who settle colonies among the Semite populations. One colony was called Sumer, which was founded by Dravidians. It's a Dravidian-speaking culture, or a Dravidian language-speaking culture. This culture, which had the characteristics of Dravidian culture, degenerated in the way in which Dravidian cultures tend to degenerate.

And thus, after the degeneration of Sumer, you had the rise of the Semitic Akkadian culture, based on the legacies of Sumer's culture. You had the development of Ethiopia, which originally was a Dravidian colony, the center of Ethiopia. What we call Yemen today, was also a colony of the Dravidians. What we call the Canaanites, or the Palestinian area today, was originally a Semite region, colonized by Dravidians, as Herodotus refers to this in his histories, and as the evidence corroborates Herodotus' commentaries.

You had another great influence on the Semites in this period: the Egyptians. And the Mosaic religion comes out of Egypt, not out of Mesopotamia. The characteristics, the food culture, the taboos, all of these things, are *characteristically Egyptian* in character. They would be anathema, in a sense, to an ancient Mesopotamian culture.

And so it was the Egyptians who were, in a sense, the authors of European civilization. But something came out of that, which was not purely Egyptian. The great accomplishments of the Egyptians, were to lay the foundations for the development of Mediterranean civilization. And the great development of

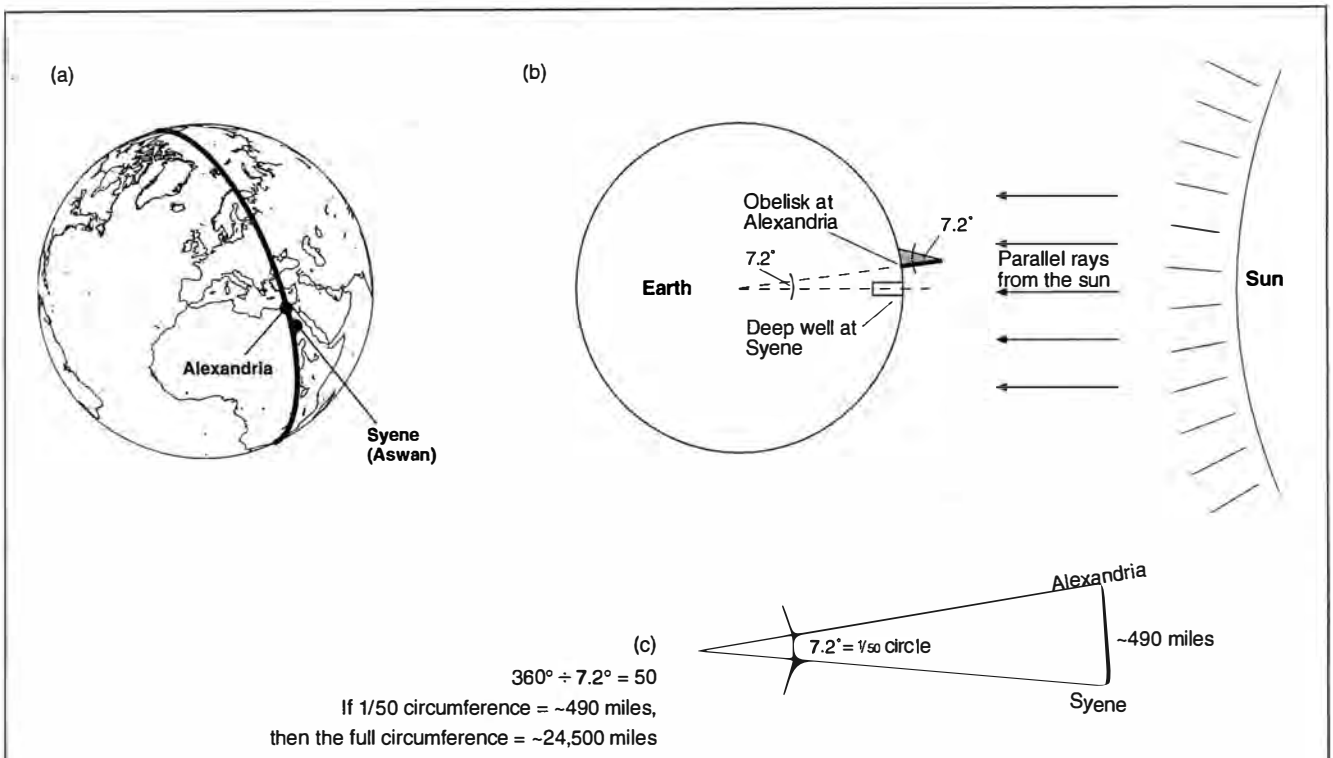


Figure 5
HOW ERATOSTHENES DETERMINED THE CIRCUMFERENCE OF THE EARTH

The cities of Alexandria and Syene (modern Aswan) lie nearly on the same meridian, about 490 miles apart (a). At a well dug for the purpose of observing, it was noted that at the summer solstice: (b) the Sun's rays perpendicularly hit the greatest depth in the well; at the same hour in Alexandria, however, it was observed that the Sun cast a shadow from the summit of an obelisk at an angle of 7.2°. With a simple calculation (c), Eratosthenes arrived at an astonishingly precise result for the circumference of the Earth.

Mediterranean civilization, came out of what we call Greek or Hellenistic civilization later.

The Classical Idea

The great tradition of European civilization, comes from people like Thales, Heraclitus, the Homeric epics; from the Great Age of Pericles. You see it emblazoned in stone, in the Athens of Pericles, in the methods of sculpture of Scopas and Praxiteles, in which the triangle, four-square conception of art was replaced, the tombstone conception was replaced, by imbalance, where the imbalance created metaphor. *The idea of metaphor in stone.*

The triangular culture, the Egyptian architecture, was symbolic. The primitive Archaic Greek culture was symbolic. It was not cognitive. Whereas what we call Classical Greek culture, from which all European civilization comes, and all its contributions to the world come, are what we call Classical culture, the Classical idea. The systematization of the Classical idea we owe largely to Plato and his Academy.

The principle of paradox, the principle of metaphor, the principle of crucial experiment, by which we recognize that any idea which is popular, is probably absurd, on that evidence alone. We therefore find the fallacy in popular belief, by driving popular belief to its extremes, extreme conditions. And we're able to demonstrate that popular belief is false, because it omits consideration of something which is a principle, which we've heretofore ignored. And by crucial-experimental methods, we generate new principles, not only principles of physical science, but principles of art. And you can't have one without the other. *The ideas of Classical art and Classical physical science, are unified. You separate them, you destroy the mind.*

Just think of an act of discovery. Now, there are people who have made an act of discovery, whether as an original discoverer, or simply replicating the original act of discovery as a student, by reworking, step by step, beginning with a paradox, getting the flash of insight which demonstrates the idea, which is the principle to be discovered, and then working through the experimental proof which demonstrates the validity of that discovered principle.

Now, think of the process that you go through mentally, in making such a discovery. You go through a process, which is *impassioned.* The first thing about scientific discovery, is *passion.* Logicians will never discover anything, except their own great burial place, which is a good place for them. *It's passion, the passion to persist, the passion not to break concentration. The passion to spend days without interruption, fighting with the problem. The passion to maintain concentration.*

What is passion? What is discovery? *It is concentration, highly energized, impassioned concentration.* You will not let

the question go. You grab it by the neck, and don't let it go. *Passion.*

And where do we recognize this passion? We recognize it in great Classical art, as opposed to so-called "popular art," which has no passion in it, only lust, which is very quick. It passes very quickly. But the persistence: A great discoverer is a person who devotes years or longer, to working through various stages of a great discovery—*passion that will not let him go. The artist: passion which will not let him go.*

Take the case of the work of J.S. Bach, the great work of passion which would not let him go—and then you get to the kind of discoveries which are concentrated in things like the "Musical Offering," or sketched out in the principle of contrapuntal inversions, in "The Art of the Fugue."

The passion that will not let you go, that commands your life from beginning—from childhood until death; the passion which characterizes Mozart in studying the work of Bach, in 1782-1783, with van Swieten at his library in Vienna, and making a discovery from within Bach, which gave us modern Classical motivic thorough-composition.

Think of Beethoven concentrating on that, in doing his later compositions, concentrating on someone from the end of the 16th century, Zarlino, and working on the work of Bach, on the "Art of the Fugue" by Bach, in preparing to work through the ideas which were expressed in his last works, including his last string quartets.

Passion! And a passion described by Plato, a passion for Truth. Do not let yourself be controlled by a false idea. Know that many falsehoods have trapped your mind. And you must never allow those traps, those beliefs, which you have learned but which you don't know; never let those guide you.

A passion for justice, which is based on the nature of Man as not a beast, but a creative mind. And that all people are sacred, not merely to exist, but they're sacred because they contain a developable potential of discovery, which enriches all mankind. And therefore, justice requires not merely the sense of justice in the ordinary crude sense for the individual, but *justice for the existence of the individual,* which means, above all, fostering the development of the intellectual powers and character of that individual.

Justice and Truth. Not letting yourself go, until you get it.

Now, this quality is described by Plato, using a Greek word, which was used with the same meaning by the Apostle Paul: *Agapē.* This *passion,* this love for mankind, this passion for truth and justice, which in the *Republic,* in Plato's *Republic,* distinguishes Socrates from Thrasymachus, the Adolf Hitler of the lot, and from Glaucon, the formalist. It's that kind of quality.

Power Over the Universe

Now, how do you develop that kind of quality? Because you must not only have the insight into the way the Universe is organized, but you must see that *man is increasing man's power over the universe.* So, you have to look at man, not dead nature. Not sticks and stones. You have to look at *how man's mind functions. How does man's mind function to control the universe, to improve our power over the universe, by means of which we exist, by means of which we develop.*

What is that? This is called Classical art. You don't like something because it "feels good." That's irrationalism. That's Thrasymachus. That's evil. Rock music is *evil.* If you like rock, you are partaking of evil per se, because you've rejected truth and justice for passion of a cheap kind—mere lust.

And thus, you must have a critical sense about man, a critical sense about the mind, a critical sense about how people work together, or don't work together. It is that passion for truth and justice, which evokes the power to concentrate on a discovery; the power to go higher and deeper than ever before, to go further in the direction of largeness and smallness than ever before. The passion to say "The universe is there, therefore, we've got to go out and explore it." You can't just sit back and use logic for that. You have to ennoble it with a passion for truth and justice.

So, we had that. And you had a person who is characteristic, who lived toward the latter half of the 3rd century B.C., Eratosthenes. He was a poet, a geometer, a scientist, a nation-builder, a culture-builder. You had in Archimedes, who was perhaps not as brilliant a character, not as profound a character as Eratosthenes, but nonetheless the same thing, you had Roman soldiers killing this precious mind in Syracuse, as they tried to kill Etruscan culture, and suppress all other cultures.

And you realize that the legacy which makes the difference in going from the greatest aspect of Greek and Hellenistic culture, as typified in the heritage of Eratosthenes and Archimedes, and people like that, to the rise of Roman culture and what that represented, was a great crime against humanity, from which civilization only *began* to recover in the 15th century, in the Renaissance.

And then you look more closely, at the fine details of this process, and you see more deeply, that Toscanelli had not yet reached the intellectual level of Eratosthenes.

Figure 5 shows a simple description of the famous simple experiment. It is known that long before Eratosthenes, the Egyptians did astronomy with the aid of deep-well observations. That is, you dig a very deep well—and you could do that in countries where you had to dig deeply to get water. And if you look up from a deep well, you can see the stars at midday. That is, if there's not too much haze in the sky. And that method was commonly used by the Egyptians in earlier periods, the deep-well or similar kinds of observations. Line-of-sight studies.

So, observing at a place near what we call Aswan today, which was then called Syene, Eratosthenes made a measurement of the midday position of the Sun, and compared it to the same position at a similar site in Alexandria.

And by this study and other studies related to it, Eratosthenes was the first to estimate, with reasonable accuracy, the size of the Earth as a spheroid, and came within, relatively speaking, a very small margin of error. He also made other estimates, which we didn't record here, of the distance from Alexandria to Rome, along the arc of a great circle. And by this same method, he calculated the possibility of demonstrating how this would work for transoceanic navigation, going from Egypt to Egypt by way of the Pacific, into the Great Ocean, which is the Atlantic, and back into Egypt.

That was the experiment.

Or, for example, take another case. The famous Sieve of Eratosthenes, which again in the 19th century, became ex-

tremely significant to us, as was demonstrated by Georg Cantor in his writings toward the end of the 19th Century, in dealing with a problem he called *cardinality,* which deals with how we make measurements, in terms of processes, which are characterized as multiply connected manifolds of the Gauss-Riemann form.

So you see, if you look at the internal work of an Eratosthenes, at the internal work of Plato and other members of the Academy earlier, you see a profundity of mind, a precision of mind visible from a modern standpoint of modern science, which is greater than anything in the intervening period.

You say "What happened to this?" Well, very simple. The method used by Eratosthenes and his associates, is well documented. It is the Platonic method, the Platonic method of Classical art forms, the Platonic method of physical science.

What happened to that method? That method went out of use. And while that method went out of use as a controlling influence in shaping society, society went, for over 1,700 years, into a long period of degeneration, of European culture. And it was not until the Renaissance of the middle of the 15th century, *when this specific method was revived, and studied and revived,* that Europe began the process of rising to and above the level of intellectual culture, which it had had in the time of Eratosthenes.

So, when you look at this exploration of Eratosthenes' student Maui—the "eyes of the dragon," so to speak—you say, "Well, why did 1,723 years pass between the discovery, or declaration of discovery of South America by the navigator Maui, and the similar discovery, the similar voyage of exploration, conducted by Columbus?" Why did 1,720-odd years have to pass?

Because of a great degeneration of culture. And therefore, when we look at European civilization today, and its legacy, *that is the first measuring rod you must apply to understand the history of European civilization.* You have to account for a crucial fact, that from the time of the rise of the Romans until the Renaissance, European civilization was in a process of moral and intellectual degeneration. And we have not fully corrected that error yet.

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

Notes

1. The 3rd century B.C. Egyptian voyage, under the direction of Captain Rata and Navigator Maui, as reported in inscriptions deciphered by Barry Fell, is discussed in a series of articles in *Executive Intelligence Review*, Nov. 20, 1998, pp. 14-33, including "Scrapping the Usual Academic Frauds—'Go with the Flow': Why Scholars Lied about Ulysses' Transatlantic Crossing," by LaRouche.
2. After Barry Fell had deciphered the 3rd century B.C. inscriptions of Maui in the Caves of the Navigators, in Irian Jaya (western New Guinea), he predicted that other inscriptions from the voyage would be found in the Americas, dating from a year or two later. A report on such an inscription, found in a cave near Santiago, Chile, and translated by Barry Fell, appears in the Winter 1998-1999 issue of *21st Century,* "The Decipherment and Discovery of a Voyage to America in 232 B.C.," p. 62. How the inscription was originally discovered in 1885, appears on p. 66, in "Indian Inscriptions from the Cordilleras in Chile."
3. The rock inscription describing an Egyptian shipwreck at Pitcairn Island was deciphered by Barry Fell, and published in *The Epigraphic Society Occasional Publications*, August 1974.
   For more information, contact the Epigraphic Society, Donal B. Buchanan, Secretary, 8216 Labbe Lane, Vienna, Virginia 22182-5244, or e-mail donalb@aol.com.

Homer's Odyssey, Long-distance Seafaring, And the Principle Of Colonization

by Gabriele Liebig

Homer prepares his fellow citizens not only for a renaissance of Greek culture in 800 B.C., but for a mission of colonizing more primitive societies in the Mediterranean region and beyond.

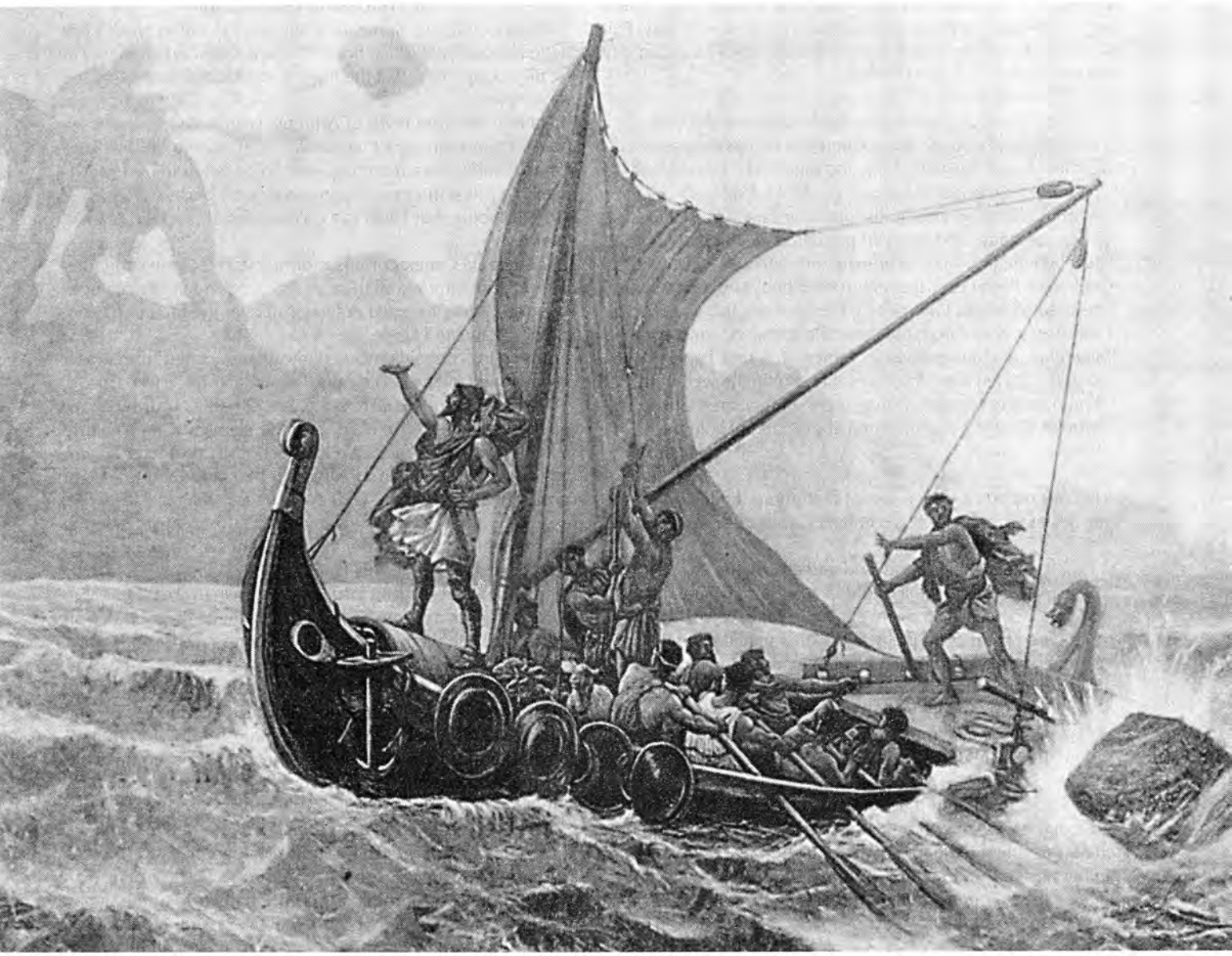
Human history is not an orderly ascension in stages from so-called primitive man to the glorious present, but rather a succession of ebbs and flows: dark ages followed by renaissances and progress, then backsliding again to new, relatively dark ages.

There is an underlying line of upward development, but it is not automatic. In early history, especially during the 100,000-year-long ice age cycles, development was mediated by maritime cultures, the "peoples of the sea," who now, finally, must receive their deserved rank in human history.[1]

Humanity's development was always carried forward by great-minded individuals who organized renaissances. Such people were Homer and his friends in ancient Greece in the 8th century B.C., when his wonderful epics, the *Iliad* and *Odyssey* reportedly were written down.

Because Homer's epics mark the beginning of a renaissance in Greece, after 300 years of a relative dark age, German historians call it "die dunkle Zeit" (the dark time) from the middle of the 12th century to the 8th century B.C., when the Greek colonization of the Mediterranean started.

At about the same time, around 1150 B.C., when Troy was destroyed, the great Mycenaean palaces were also destroyed. Mycenae was the home town of Agamemnon, the commander-king of the Greek fleet that, after 10 years of war, ravaged Troy. However, Troy itself, and many other cities in Asia Minor, were part of the same Mycenaean culture that probably was destroyed by invaders from the north. Whatever happened, the *Iliad* gives an idea of that terrible world war during the 12th century B.C. The ensuing dark age was characterized by waves of mass emigration from the Greek mainland, a



The Granger Collection

Odysseus defying Polyphemus, who is blindly hurling rocks at the ship, as depicted in an 1887 oil painting by Fredéric Schutzenberger.

severe reduction in the potential relative population density, poverty, and isolation.

The *Iliad* tells about that disastrous war against Troy, launched for no good reason (the ostensible reason was Helen's "Lewinsky affair"). It was a terrible thing, despite all the bravery of its heroes. And Odysseus—as chief responsible for the destruction of Troy—is then condemned by the gods to a 10-year odyssey. Odysseus' punishment, however, is not the main subject of Homer's second epic. Rather, two other ideas are:

(1) preparing his listeners for a renaissance of the higher culture that existed before the dark age; and

(2) inspiring them to go to heretofore unknown parts of the world, and to colonize there.

Homer tells about the old culture that has perished. For example, he talks about Crete (which had been under Mycenaean rule since 1400 B.C.). Odysseus is particularly fascinated with Crete, and he tells his wife, Penelope, that in addition to the marvelous city of Knossos, there were 90 other cities on that island. Homer reports about Agamemnon's Mycenae, about Nestor's Pylos, about Menelaus' Sparta, and about the highly developed agriculture in Odysseus' home-island, Ithaca.

The crucial concept in the *Odyssey* is the idea of colonization: Instead of just leaving one's homeland as hungry refugees, the idea is to colonize other places! Thus, we see the overriding significance of the ideal seafaring city-state of the Phaeacians on the fantastic island Scheria—Odysseus' saviors, who finally bring him back home in their most effective and most secure ships, that are "swift like thoughts." His raft being de-

stroyed by Poseidon, Odysseus swims to Scheria's shore, and he is welcomed, even though a stranger, in a friendly way. Full of admiration, Odysseus wanders through the Phaeacian city and harbor. Let us quote Homer:

> And Odysseus marvelled at the harbors and the stately ships, at the meeting-places where the heroes themselves gathered, and the walls, long and high and crowned with palisades, a wonder to behold. . . . [7.43-45]
>
> [B]ut Odysseus went to the glorious palace of Alcinous. There he stood, and his heart pondered much before he reached the threshold of bronze; for there was a gleam as of Sun or Moon over the high-roofed house of great-hearted Alcinous. Of bronze were the walls that stretched this way and that from the threshold to the innermost chamber, and around was a cornice of cyanus [lapis lazuli]. Golden were the doors that shut in the well-built house, and doorposts of silver were set in a threshold of bronze. Of silver was the lintel above, and of gold the handle. [7.84-90]

Homer reports a very relevant fact about the history of the Phaeacians: Scheria itself is a colony!

> . . . Athena went to the land and city of the Phaeacians. These dwelt of old in spacious Hypereia hard by the Cyclopes, men overweening in pride who plundered them continually and were mightier than they. From thence Nausithous, the godlike, had removed them, and led and settled them in Scheria far from men that live by toil. About the city he had drawn a wall, he had built houses and made temples for the gods, and divided the ploughlands. [6.2-10]

We know what kind of barbarous people Cyclopes are, because of the well-known ogre Polyphemus. But Homer characterizes this brand of people more in detail. The Cyclopes know neither agriculture nor ship-building, and Odysseus, who reports all that, proposes that seafaring people should come and teach them those skills:

> Neither with flocks is it held, nor with ploughed lands, but unsown and untilled all the days it knows naught of men, but feeds the bleating goats. For the Cyclopes have at hand no ships with vermilion cheeks, nor are there ship-wrights in their land who might build them well-benched ships, which should perform all their wants, passing to the cities of other folk, as men often cross the sea in ships to visit one another—craftsmen, who would have made of this isle also a fair settlement. For the isle is nowise poor, but would bear all things in season. In it are meadows by the shores of the grey sea, well-watered meadows and soft, where vines would never fail, and in it level ploughland, whence they might reap from season to season harvests exceeding deep, so rich is the soil beneath. [9.123-135]

In other words, the Cyclopes are ancient ancestors of today's Greens (Don't change nature, just be ugly!), and Prince Philip has certainly a fitting forefather in Polyphemus.

The Principle of Colonization

The principle of colonization is at least as old as Noah's Ark at the time of the Biblical flood. Perhaps this was historically at the time when the ice of the last ice age melted, and raised the ocean levels.

There is also the myth of Atlantis, which sank into the sea thousands of years ago. Plato renders the story in his dialogues *Timaeus* and *Critias*, reporting what Solon was told by a knowledgeable priest in Egypt. I mention it here, because this priest also tells Solon that Egypt is a colony of that perished Atlantic culture.

Then came Greek colonization. First, the Greeks founded cities in Asia Minor, and then, in the 8th through 6th centuries B.C., the Greeks founded colonies all over the Mediterranean, in Sicily, Italy, and Egypt.

Cyrene in Cyrenaica, where Eratosthenes comes from, was a colony founded by people from Thera (Santorin, 630 B.C.).

We know about Solon, his friend Thales, and, later on, Aeschylus, and the rise of Athens and classical Greek culture in the ensuing centuries. We know about Plato's Academy in the 5th century B.C., and Alexander's campaign in the 4th century B.C., his conquest of Egypt, the founding of Alexandria in Egypt with the famous library that Eratosthenes headed in the 3rd century B.C. (At the time of Maui's voyage, 232 B.C., Eratosthenes was in his 40s.)[2]

And that astounding process begins, in a sense, with Homer's epics and the broad education of the population connected with them. When these "stories" were sung during festivities or in public places, this was the "aesthetical education of man," in Friedrich Schiller's meaning of the word. The poetry of the epics increased the listeners' attention span, and introduced a higher form of language.[3] The higher the language, the more complex are the ideas that can be transmitted. Strabo, a geographer-philosopher in the 1st century B.C., considers poetry an "elementary philosophy" and an indispensable means of education of character, emotions, and actions of man. And, he says, while "philosophy is for the few . . . poetry is more useful to the people at large and can draw full houses—and this is exceptionally true of the poetry of Homer." Old Strabo, who is a real fan of Homer, also says, that in order to be a good poet, one must first of all be a good person. And he emphasizes how much this is true for Homer, who had been a universally learned person, who eagerly tried to transmit all his knowledge to the people listening to his poetry.

Homer's *Odyssey*, in particular, was *the* schoolbook for Greek children. The last version, as we know it today, was edited in the Academy of Alexandria. It is a "school of life," animating children to become a leader like the hero Odysseus, while avoiding his mistakes, and, last but not least, to learn everything relevant about the known and the unknown world—geography.

The Riddle of the *Odyssey*

Now we come to the actual subject: the whereabouts of Odysseus' voyage. To warn you, the *Odyssey* is not a *periplus* (or ship's log-book) of a specific historical voyage of a historical king Odysseus. Odysseus may have existed, and those voyages certainly took place, and various reports about them had reached Homer. But the real question is: What did Homer

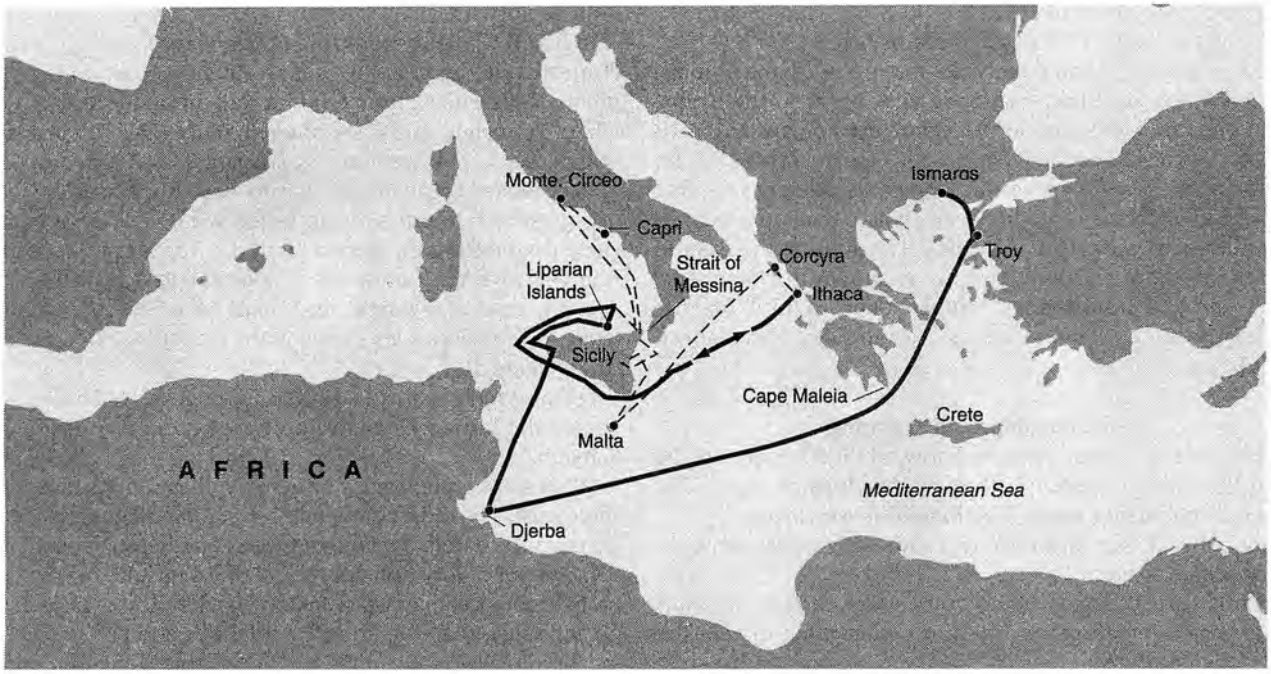


Figure 1
MAP OF THE ODYSSEY FOR THE SMALL-MINDED
The prevailing view of Homer's Odyssey *is that it takes place exclusively in the internal sea, the Mediterranean.*

want to say, and what could he know about long-distance sea-voyages in about 800 B.C.?

As Homer is geographically very precise in some parts, while in other parts quite ambiguous—deliberately ambiguous, I would say—a great controversy arose in antiquity about the *Odyssey,* concerning the most dangerous and most dramatic part of Odysseus' journey: Whether Homer places the journey in the external sea, the Atlantic Ocean, beyond the "Pillars of Hercules" (the Strait of Gibraltar), or whether he places the whole trip exclusively in the internal sea, the Mediterranean, not going farther west than Sicily and the west coast of Italy (Figure 1). The latter, small-minded outlook, is the view of British scholars, which prevails today in most of the literature.

Of course, this is only one of several versions, which often contradict each other.

In summary, this view of Odysseus' trip leads from Troy via Ismaros and Cape Maleia to the Lotos-eaters (whom Strabo places quite plausibly in Djerba, an island off the North African coast. Next, they come to the Cyclopes (putatively in Sicily), the Aeolean islands (the Liparean islands north of Sicily are still called that), almost home to Ithaca, and straight back to the Aeolean or Liparean islands. So far, we can agree.

But then the small-minded interpreters place the Laistrygonians once more in eastern Sicily, and Circe at Monte Circeo in Italy (a place which got its name, of course, much later). And some go so far as to ridiculously locate the entrance to Hades, the realm of the dead, at the Avernean Lake in Italy. The Sirens are then located close to Capri; Scylla and Charybdis are equated with the Strait of Messina; Helios' island Thrinacia is, for the third time, located in Sicily, this time on the east side; Calypso's island is equated with Malta on Pentelleria; and Scheria is placed not "at the end of the world," as Homer specifies, but at Corcyra, not far from Ithaca.

The other faction, the "ex-oceanists"—including myself, of course, and, not surprisingly, Eratosthenes—argued that, no, the last phase of the *Odyssey* is placed in the external sea, the Atlantic Ocean! (See Figure 2.)

Here, also, other versions of the journey are possible, because Homer leaves us with ambiguity. We will look at this map more in detail later.

Eratosthenes was of the opinion that Odysseus did sail out into the Atlantic, although he was very critical of those who took every word of the *Odyssey* absolutely literally, and who were looking for details, such as the shape of rocks, in order to locate the mentioned localities. Strabo reports that Eratosthenes said, it were as likely to find some of those localities as to find "the cobbler, who made the bag, in which Aeolus put all the winds." Unfortunately, the three volumes of Erathosthenes' work on geography are lost, and only fragments are reported by Strabo and others.

Like Strabo, Eratosthenes considers Homer the "founder of geography," because of his precise descriptions of the known world. However, Erathosthenes sees the need to revolutionize the traditional anecdotal geography, and on the basis of his geometrical-astronomical achievements, he is able to establish a much more precise method of map-drawing, in which places are defined by their position in terms of longitude and latitude.

Homer measures distances in terms of days of travel required, and he describes directions by naming the respective winds---except for one crucial case, in which he indicates the direction by a star constellation.

Shown in Figure 3 are four ancient world maps, according to the specifications of Hesiod (700 B.C.), Hecataeus (517 B.C.), Herodotus (440 B.C.), and Eratosthenes (200 B.C.).

Homer's "map" should be closer to the truth than Hesiod's, in which, for example, Cyprus is missing. Also the Arabs, mentioned by Homer under the name Erembeans, are missing. And if Hesiod equated Sicily with Thrinacia (Trinakria on his map), this is simply an error. Homer also clearly says, that the Ethiopians are divided between "where the Sun rises, and where the Sun sinks"; that is, they live on both the eastern and the western shore of Africa—as shown in Hecataeus' map. And like Eratosthenes, Homer seems to think that the external sea, the Atlantic Ocean, is on all sides of the known world.

Ancient Ships and Seafaring

But how did Homer come to know all this? Reportedly, he used Phoenician *periploi,* that is, ship logs or reports by Phoenician seafarers about their long-distance voyages.

And what do we know today about early transatlantic or transpacific voyages?

In this respect, Barry Fell's book *America B.C.* contains some very interesting information.[4] According to Fell, the first accidental drift-voyages, via the Canary Islands across the Atlantic, by Iberians and Libyans, occurred 5,000 years ago; and deliberate transatlantic voyages were undertaken starting in 1000 B.C. As evidence, Fell presents Ibero-Celtian, Phoenician, Egyptian, and Libyan inscriptions in North and South America. For example, there is a stone engraving found in Oklahoma, dating from as early as 800 B.C., showing a picture of the Sun with rays, with a quote from the Egyptian "Hymn to the Sun" by Pharaoh Akenaton from the 14th century B.C.

In 800 B.C., Fell reports, the Phoenicians founded Tarshish (Tartessus or Tarsis) at the Iberian Atlantic coast (outside the pillars of Hercules), from whence they imported gold, silver, and other metals. The Book of Jonah in the Old Testament reports a stormy passage from Phoenicia at the easternmost bank of the Mediterranean, all the way to Tarshish. This is the same trip, in which Jonah ends up in the whale. When invaders came from the North, around 500 B.C., Tarshish disappeared. And, Fell says, the Tartessians disappeared to America.

In any case, at that time, there must have been busy transatlantic trade relations, as shown in the map adapted from Fell's book (Figure 4).

Fell also reports, that in 1200 B.C., huge Egyptian ships traversed the Indian Ocean to gold-rich southern Africa and Sumatra.

What ships were used? Fortunately, illustrations of ancient ships exist. The oldest drawing I have found (Figure 5), shows Egyptian ships from the time of Queen Hatshepsut, about 1500 B.C. The relief very distinctly shows ships (a) and (b) with dual propulsion: a central mast, yard, and large sail, and 15 oarsmen on each side, who row the ship at launch and before anchoring, or in battle, or when there is no suitable wind. The ship in (c) is a cargo ship used to transport obelisks. Here, mast and sail are missing; instead, there are three lines of holes for oars.

Figure 6 is an 8th century B.C. illustration of the Phoenician fleet. These are war ships, and you see the shields of the soldiers, who also do the rowing. Again, the ships have mixed propulsion: oars for battles, sail for long-distance voyages. The urn, Figure 7 (a), shows Odysseus' ship. Unfortunately,

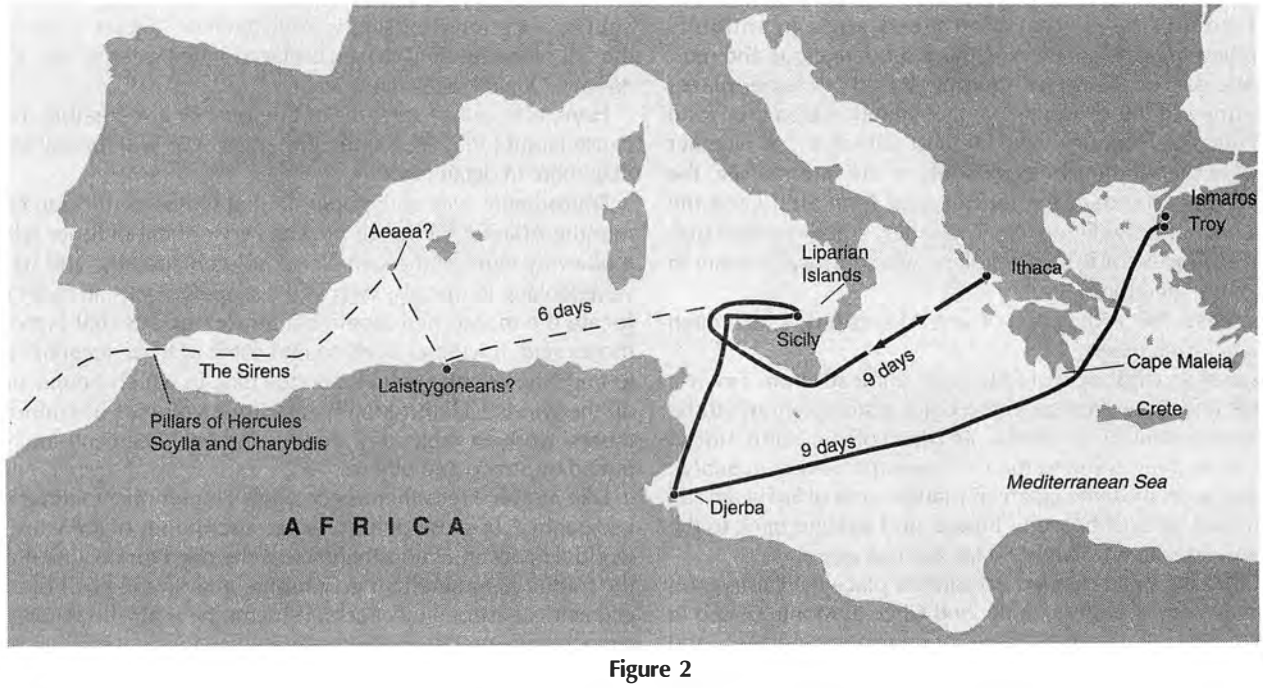


Figure 2
MAP OF THE ODYSSEY ACCORDING TO THE 'GREATER HYPOTHESIS'
In the view of the ex-oceanists, including Eratosthenes, the last phase of the Odyssey *takes place in the external sea, the Atlantic. This view is discussed in more detail below.*

for our purposes, the illustration is more concerned with the Sirens than with the technology of the ship! In reality, Odysseus' ship, and most of the other 12 ships he commanded on the way back from Troy, are described by Homer as pentekontei, with two rows of 25 oarsmen on each side. Such ships were about 25 meters long, 2.5 meters wide, and could cover 130 km a day.

The other two Greek ship illustrations, Figure 7 (b) and (c), are triremes. They have two lines of oars on two separate levels. Later, the Greeks developed the famous triremes with up to 170 oarsmen on three different levels.

The Romans simply copied Greek ships. The Roman river ship in Figure 8 was reconstructed by the Museum for Ancient Ships in Mainz, Germany, after workers found a wreck in a large construction site near the Rhine. Although this is a river ship, and less curved than Greek ships, it works according to the same principle. Remember, however, that Homer describes the Greek ships as "blackish," that is, painted with tar, and sometimes "with vermilion cheeks." These ships had a removable mast, a square sail that could be moved into the winds by braces, and could be shortened by small ropes; they also had a lateral rudder to steer.

Viking ships, such as the one portrayed in Figure 9 in a painting by Gerhard Geidel, have similar features. With such ships, Leif Ericsson and his Viking comrades arrived in the year 1000 in America, approximately where New York is today.

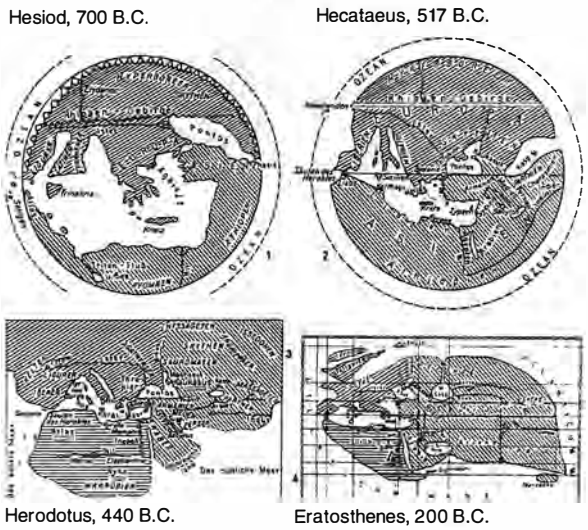


Figure 3
FOUR MAPS OF THE ANCIENT WORLD
Homer's knowledge of geography, which was more advanced than that shown on some of these maps, reportedly came from the ship logs of long-distance Phoenician voyagers.

Four Levels of Seafaring

We can understand the *Odyssey* and Homer's geography of sea voyages, only by distinguishing four types or categories of sea voyages. If we lump all the voyages together, we can't make sense of it.

The first level is *coastal shipping.* If we were to apply a modern analogy, we would compare this to travelling by regular airplane. Homer's example is the overnight trip by Odysseus' son, Telemachos, who takes a small ship to Pylos, because he wants to ask Nestor, whether he has heard anything about his father's fate.

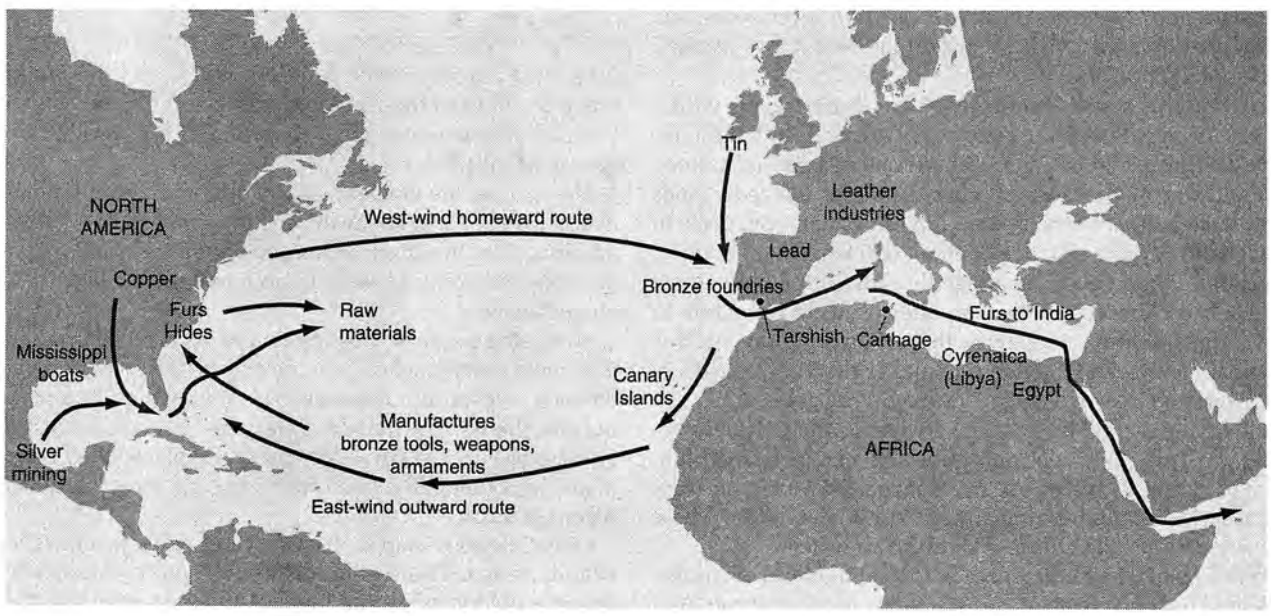


Figure 4
TRANSATLANTIC TRADE ROUTES, 500 B.C.
(ADAPTED FROM BARRY FELL)
Fell and others have documented that long-distance maritime trade flourished going back at least to 3,000 years B.C.

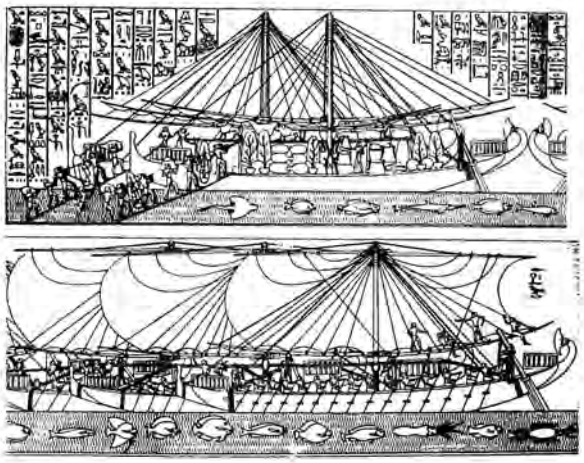


Figure 5
EGYPTIAN SHIPS, 1500 B.C.

These illustrations of a relief from the time of Egyptian Queen Hatshepsut, about 1500 B.C. show seagoing ships propelled by sails and oars.

Source: After A. Marietle, *Deir-el-Bahari* (Leipzig 1877), as reproduced in Lionel Casson, *Ships and Seamanship in the Ancient World*. Copyright © 1971 by Princeton University Press. Reprinted by permission of Princeton University Press.

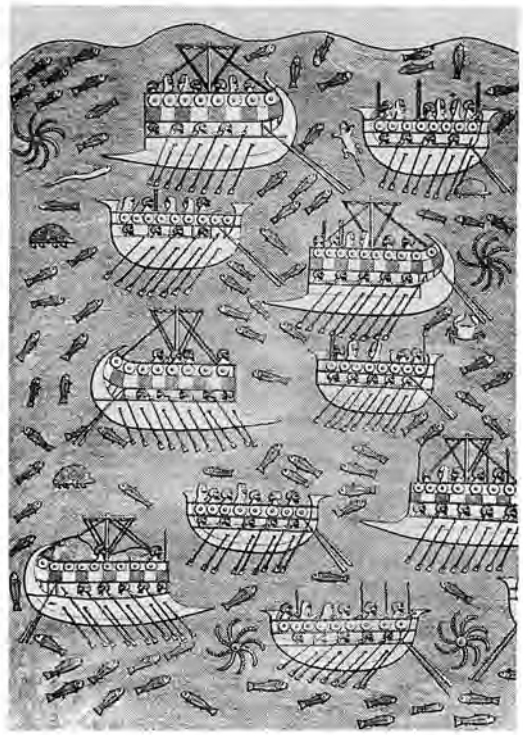


Figure 6
PHOENICIAN FLEET, 700 B.C.

This drawing of Phoenician two-banked warships and transports c. 700 B.C., from a relief in the Palace of Sennacherib, shows both sail and oar driven ships, with soldiers rowing.

Source: After A. Layard, *The Monuments of Nineveh* (London 1849), as reproduced in Lionel Casson, *Ships and Seamanship in the Ancient World*. Copyright © 1971 by Princeton University Press. Reprinted by permission of Princeton University Press.

The second level concerns *long-distance voyages in the Mediterranean Sea* between known, clearly identified places (figure 10). The modern analogy might be flights with the Space Shuttle, to Mir, or the new space station, or even back to the Moon.

Homer tells about Menelaus' return from Troy, via Lesbos and Cape Maleia. Then, a storm wrecks the other ships nearby Crete, while Menelaus' own ship is driven farther to Egypt. Menelaus and Queen Helen stay in Egypt for seven years, and during that time they visit Thebes on the Nile, Libya, Arabia, Cyprus, and Phoenicia.

Also on this same second level are those travels which Odysseus invents as plausible "cover stories." Both these invented voyages start in Crete: The first one is supposed to bring him to Pylos, but because of bad weather, he allegedly lands by mistake in Ithaca. The second trip brings him from Crete in five days to Egypt (a distance of about 650 km, which is totally plausible). From Egypt, he allegedly sails with a Phoenician gangster to Phoenicia. This man later wants to bring him to Libya and sell him into slavery there. A storm prevents this from happening, and Odysseus comes to the Thesproteans in northwestern Greece, or so the invented story goes.

Still on the second level is the very first part of Odysseus' return from Troy. Odysseus tells about the massacre and plundering of the city Ismaros in Thrace, not far from Troy, and says that they then sailed southward to Cape Maleia, from where they were thrown off course into unknown waters.

At this point, Homer proceeds onto the third level of voyage: *sailing in unknown waters, but still in the Mediterranean.* As a modern analogy, we might compare this third level to voyages to other planets, colonizing Mars, and so on.

We can follow Odysseus' route on the map, Figure 2. From Maleia, it takes them nine days to reach the land of the Lotus-eaters, which the Greek geographer Strabo (1st century B.C.) places in Djerba. Thucydides and the Sicilians place the land of the Cyclopes in western Sicily. Why not? We can also agree to placing Aeolia at the Aeolian or Liparean islands.

Then comes the nine-day trip, almost to Odysseus' home in Ithaca: This is 1,200 km away, and the ship makes 130 km per day. But then the stupid comrades open the wind bag, and promptly the storms blow them back to Aeolia, where they are chased away.

Next, after six days' crossing on the open sea, they come to the cruel Laistrygoneans, who destroy all the ships and kill all the men, except for Odysseus' own ship, which he anchored outside the narrow harbor. Solely because of the distance given (6 days × 130 km = 780 km) I have placed the Laistrygonians, hypothetically, in North Africa, approximately where Algeria is today.

Only Odysseus' ship is able to escape, and it reaches Circe's island, Aeaea. There is no distance given by Homer; thus Aeaea is not locatable, but it is still on the Mediterranean side of "Scylla and Charybdis."

Circe is a witch. She doesn't show him the way home—as Calypso, the nymph, will do later on. On the contrary, Circe now sends him onto the most extreme, most arduous part of his trip: out into the external sea, the Atlantic. And here is

Figure 7
ILLUSTRATIONS OF GREEK SHIPS
The illustration on the urn (a) depicts Odysseus and the Sirens. The other two illustrations, (b), fragments from vases, show dieres, with two levels of oars, c. 600 B.C.

where the fourth level of seafaring starts—*exploring the unknown;* for this, the modern analogy of leaving the solar system may be chosen.

Our "ex-oceanist" thesis has been backed up so far with a *historical argument,* using evidence of early transatlantic trips, the existence of suitable ships, and the possible availability of Phoenician or other *periploi* to Homer.

Now, we will employ an even stronger argument for the "ex-oceanist" thesis, namely, an argument considering the internal laws of Homer's poetry, and considering the psychology of dangerous long-distance voyages.

Eratosthenes, according to the geographer-historian Strabo, emphasized that travelling across the external sea (as his friend Maui did, on the opposite, Pacific route) is primarily a psychological problem, a problem of courage, and much less a technical problem. The explorer Thor Heyerdahl and his friends in 1947 travelled 8,000 km on the raft Kon-Tiki from Peru to Polynesia, which took this kind of courage, even though they had some radio connection, and at least the potential for being rescued.

Homer knew, too, that such a voyage into "the unknown" requires extreme courage. And he lets his hero Odysseus display such courage, a courage involving the readiness to die in the undertaking. Indeed, Odysseus and his companions agree to go to Hades first, before they continue the trip, even though they are horrified by the prospect. They sail across the world ocean to the realm of the dead.

(Homer, it should be noted, uses the word "ocean" in two meanings: First, as the water from which the Sun rises in the morning and sets into at night, that is, the horizon; and second, as the river separating the realm of the living from the realm of Hades, where the souls of the dead live. The usual Greek word for sea is *thalassa,* and there are two seas referred to, one on either side of the "Pillars of Hercules"; there is the *eso thalasses* and the *exo thalasses,* the internal and external seas.)

Odysseus and his companions visit the dead and speak to them; in particular, they hear the prophecy of the old blind prophet Tiresias about Odysseus' fate. They stand this part of the test, and upon their return Circe greets them:

"Rash men, who have gone down alive to the house of Hades meet death twice, while other men die but once." [12.22-23]

Test No. 2 is the Sirens, which have to be passed. The issue is less how they sing, but what they sing! The Sirens sing, how great a hero Odysseus is! The lesson is clear: Don't let yourself be distracted from your mission by all-too-sweet flattery. With the help of certain precautions, Odysseus and his companions stand this test, too.

Then comes Scylla and Charybdis. I think this is really a multifaceted metaphor.

- Geographically, it is the gate from the internal to external sea, as "ex-oceanists," such as Eratosthenes see it.
- In terms of seafaring, the twin dangers of Scylla and Charybdis typify and exaggerate the common features of all

Figure 8
MODEL OF A ROMAN RIVER SHIP
The Romans copied the Greek ships. This river ship was reconstructed by the Museum for Ancient Ships in Mainz. The ship has mast, movable sail, and rudder.

Source: Hartwig Dannenberg

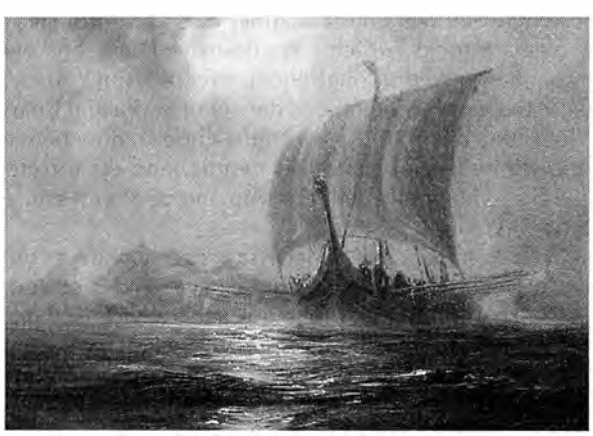


Figure 9
VIKING SHIP, C. 1000 B.C.
The Viking ship, which traversed the Atlantic, was similar in design to the Roman ship.

Source: Schiffahrt und Kunst aus Schweden, Katalog, Hansa-Verlag Hamburg, p. 99

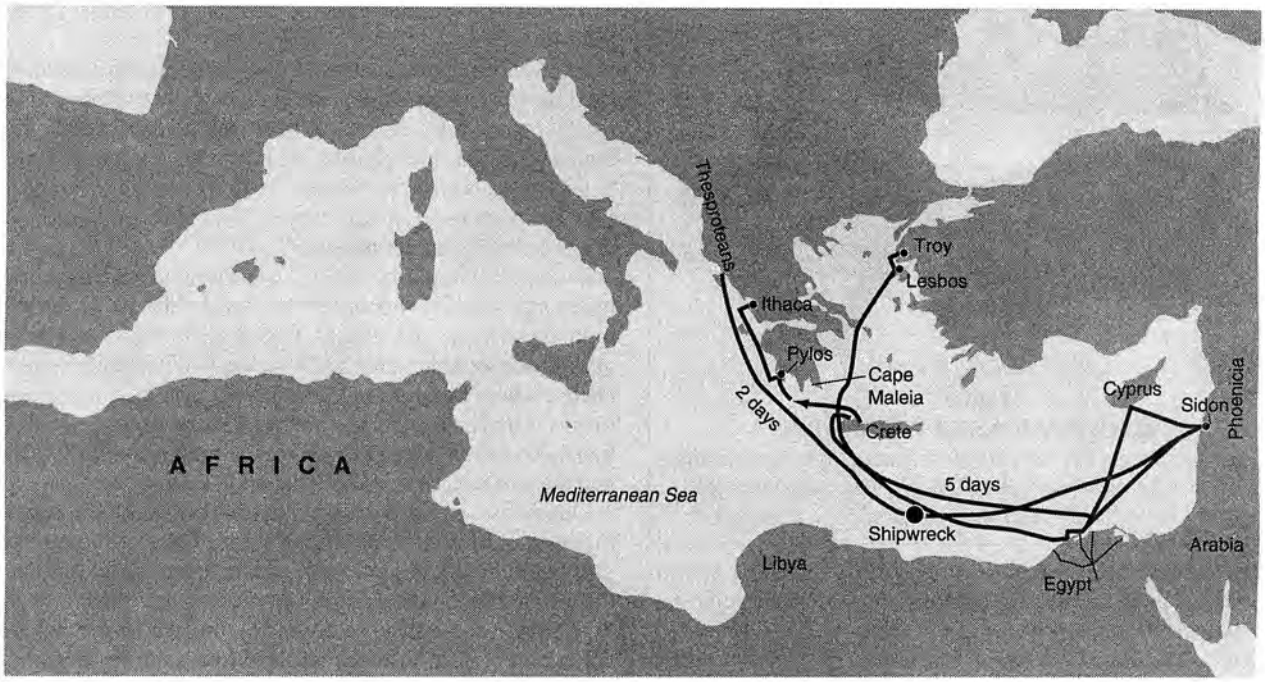


Figure 10
LONG-DISTANCE VOYAGES IN THE MEDITERRANEAN
In this second level of seafaring, we include the voyages of Menelaus, and Odysseus' invented journeys.

such narrow straits, the Bosporos, as well as the Strait of Gibraltar, or the Strait of Messina. And these dangers indeed show some specific features of the Strait of Messina; namely, the changing direction of the current of Charybdis, who is described by Homer as thrice a day swallowing the waters, and as many times spitting them out again.

• The most famous meaning of Scylla and Charybdis, however, is the metaphorical one. First, Odysseus has to choose between two courses. Either he steers through a region of sharp rocks, which have destroyed each and every ship that has passed through them, except Jason's *Argo;* or, he faces the more differentiated danger of Scylla and Charybdis. And here again, Odysseus must choose, now between Scylla, who will grab six of his people, and the torrent of Charybdis, who would sink the ship and destroy it entirely, with no survivors.

Such terrible moments of necessary decision are a crucial and recurring problem of generalship, in war and in other dangerous situations. Odysseus follows Circe's advice, and orders his companions to steer the ship close to Scylla's rock, without telling the crew about the prospect of losing six comrades. Was Odysseus right or wrong in withholding this information? Homer leaves it to the reader to think about this question. But Odysseus and his companions do get through the strait, and out into the external sea.

Then comes Thrinacia and the test which Odysseus' comrades flunk. Both Circe and the soul of Tiresias had warned Odysseus to avoid the sun god's island, Thrinacia. If he could not avoid landing there, they said, he should not, under any circumstances, kill any of the cattle or sheep on the island. If he did, they said, all his companions would die, and Odysseus alone would return home, but a very unhappy man.

When Thrinacia is sighted, Odysseus gives the order to sail on, and not to land there. A particular coward among the comrades, Eurylochus, at this point organizes a mutiny. Odysseus describes the situation:

> So I spoke, but their spirit was broken within them, and straightway Eurylochus answered me with hateful words:
> "Hardy art thou, Odysseus; thou hast strength beyond that of other men and thy limbs never grow weary. Verily thou art wholly wrought of iron, seeing that thou sufferest not thy comrades, worn out with toil and drowsiness, to set foot on shore, where on this sea-girt isle we might once more make ready a savoury supper; but thou biddest us even as we are to wander on through the swift night, driven away from the island over the misty deep. It is from the night that fierce winds are born, wreckers of ships. How could one escape utter destruction, if haply there should suddenly come a blast of the South Wind or the blustering West Wind, which oftenest wreck ships in despite of the sovereign gods? Nay, verily for this time let us yield to black night and make ready our supper, remaining by the swift ship, and in the morning we will go aboard, and put out into the broad sea."
> "So spoke Eurylochus, and the rest of my comrades gave assent." Then verily I knew that some god was assuredly devising ill, and I spoke and addressed him with winged words:

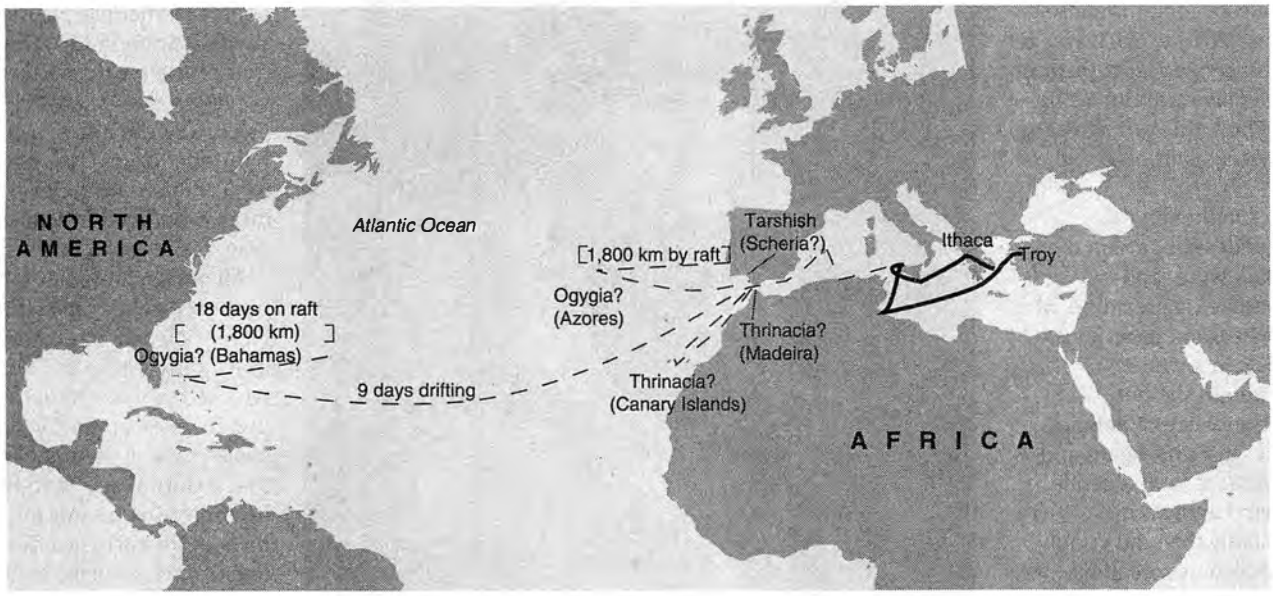


Figure 11
THE GREATER HYPOTHESIS OF THE *ODYSSEY*

The strongest argument for the ex-oceanist view of Homer's Odyssey *is the extreme psychological situations created for Odysseus and his comrades. Would Homer have Odysseus visit Hades and suffer other severe tests if it were not to prepare them for unknown adventures in the external sea? On this map, two possible locations are suggested for Thrinacia—the Canary Islands or Madeira—and two locations for Scheria—the Bahamas or Tarshish.*

> "'Eurylochus, verily ye constrain me, who stand alone. But come now, do ye all swear to me a mighty oath, to the end that, if we haply find a herd of kine or a great flock of sheep, no man may slay either cow or sheep in the blind folly of his mind; but be content to eat the food which immortal Circe gave.'"[12. 278-302]

Odysseus has no choice but to give in, but he strictly forbids his crew to kill cattle or sheep, because otherwise the sun god will go for capital punishment. At first, the crew obeys, but then there is no suitable wind for a full month, the food reserves on the ship are all eaten up, and the men go hungry. They try to catch some fish or birds, but this is insufficient. Eurylochus is going mad with hunger:

> Hear my words, comrades,. . . All forms of death are hateful to wretched mortals, but to die of hunger, and so meet one's doom, is the most pitiful. . . . Rather would I lose my life once for all with a gulp at the wave, than pine slowly away in a desert isle. [12.341-342 and 350-351]

Eurylochus wants an end with terror, rather than terror without end ("ein Ende mit Schrecken als einen Schrecken ohne Ende"). In a word, while Odysseus is asleep, his comrades kill some cows and eat them, sacrificing some to Helios (this is how Eurylochus rationalizes the act). But the sacrifice is in vain. When the ship leaves Thrinacia, a bolt of lightning destroys the ship, and all the crew drown, except Odysseus, who survives, clinging to the mast and broken keel of the ship, which he ties together with a rope.

Does this strange change of behavior of his comrades, who become mad with fear, really fit with a situation in which the ship is just circling around Sicily one more time? Does it make sense for the poet Homer to send Odysseus and his friends to Hades and through all these extreme psychological situations, if it were not to prepare them (and his audience, as well) for unprecedented adventures in the unknown external sea? This is in my view the strongest argument for the thesis of the "ex-oceanists."

Thrinacia, Ogygia, and Scheria

All that Homer says about Thrinacia is that it is a desert island, beyond Scylla and Charybdis—that is, in the external sea—but not too far away from there. After the shipwreck, Odysseus, clinging to mast and keel, is first driven back to Scylla and Charybdis. (I have put Thrinacia on the map—Figure 11—in two possible places, Madeira or the Canary Islands, but this is probably too much pure speculation.) The wreck is sucked in by Charybdis, but Odysseus waits, hanging onto a fig tree, until the wreck is spit out again. Then, with that wreck, he drifts westward for nine long days and nights, finally arriving at Calypso's island, Ogygia.

Where is Ogygia? Homer doesn't say, except for indicating that Calypso's island is the utmost western leg of the voyage. Here is how Homer formulates this message:

After seven years, Calypso, on orders from above, lets Odysseus go. She even helps him to build a raft with mast, sail, and rudder. The description is very detailed. This is an-

other important lesson for would-be long-distance seafarers: What to do, if you get shipwrecked and trapped someplace without a ship.

When the raft is ready, Odysseus sails off:

> On the raft the goddess put a skin of dark wine, and another, a great one, of water, and provisions, too, in a wallet. Therein she put abundance of dainties to satisfy his heart, and she sent forth a gentle wind and warm. Gladly then did goodly Odysseus spread his sail to the breeze; and he sat and guided his raft skillfully with the steering-oar, nor did sleep fall upon his eyelids, as he watched the Pleiads, and late-setting Bootes, and the Bear, which men also call the Wain, which ever circles where it is and watches Orion, and alone has no part in the baths of Ocean. For this star Calypso, the beautiful goddess, had bidden him to keep on the left hand as he sailed over the sea. For 17 days then he sailed over the sea, and on the 18th appeared the shadowy mountains of the land of the Phaeacians, where it lay nearest to him. . . . [5.265-280]

Corbis/Bettmann

The soul of the blind prophet Tiresias (left) counseling Odysseus in Hades, as depicted in a detail from an Attic painting, c. 400 B.C.

Odysseus sails in what direction? According to astronomer Lothar Komp, the described direction is east, very slightly northeast. He sails with good wind for 18 days, let's say 1,800 km, and then he sights Scheria.

Where is Scheria? 1,800 km east of Ogygia! If you look at the map, you will find that it is highly improbable that Odysseus, clinging to a mast and keel of his broken ship, crossed the Atlantic with the east wind drift up to where Columbus arrived. But, please consider, how could Homer have known how wide the Atlantic is? Columbus in 1492 was the first to find out! Of course, the 9 days drifting in western or southwestern direction, and the 18 days sailing by raft in the opposite direction, without again passing through Gibraltar into the internal sea, do not fit together.

What speaks against placing Ogygia among the Bahamas, is that Homer describes Ogygia as the "navel of the sea," which would place it in the middle of the Atlantic, perhaps where the Azores are. In this case, a line 1,800 km eastward hits just about the western shore of the Iberian isle. What if Homer imagined Scheria to be at the place of Tartessos (Tarshish), which he may have heard about? Homer lets Nausicaa say that Scheria lies "at the end of the world." But the context suggests that Nausicaa means the end of the inhabited world. That is true for Tarshish, in the eyes of those who lived in Homer's time.

All of this, however, is hypothesis. The only thing Homer clearly indicates, is that Odysseus is shipwrecked in the external sea, that he ends up on Ogygia, somewhere in the middle of that external sea, and that he then sails by raft for 18 days in an eastward direction to the land of the Phaeacians.

Scheria is described by Homer not only as an ideal city, but also as a kind of Garden of Eden, where fruit trees and grapes blossom and bear fruit at the same time. It reminds one of Hesiod's "island of the blessed," and of Atlantis.

And Homer reports more wonderful, fantastic things about Scheria. When the Phaeacian king Alcinous orders his trained sailors to bring Odysseus home, he explains the nature of the Phaeacian ships:

> "For the Phaeacians have no pilots, nor steering-oars such as other ships have, but their ships of themselves understand the thoughts and minds of men, and they know the cities and rich fields of all peoples, and most swiftly do they cross over the gulf of the sea, hidden in mist and cloud, nor ever have they fear of harm or ruin." [8.557-562]

The trip back home to Ithaca, therefore, takes only a single night, while Odysseus is sleeping:

> So, the goodly Odysseus . . . passed over the threshold. And with him the mighty Alcinous sent forth a herald to lead him to the swift ship and the shore of the sea. And Arete sent with him slave women, one bearing a newly washed cloak and a tunic, and another again she bade follow to bear the strong chest, and yet another bore bread and red wine.
>
> But when they had come down to the ship and to the sea, straightway the lordly youths that were his escort took these things, and stowed them in the hollow ship, even all the food and drink. Then for Odysseus they spread a rug and a linen sheet on the deck of the

hollow ship at the stern, that he might sleep soundly; and he too went aboard, and laid him down in silence. Then they sat down on the benches, each in order, and loosed the hawser from the pierced stone. And as soon as they leaned back, and tossed the brine with their oarblades, sweet sleep fell upon his eyelids, an unawakening sleep, most sweet, and most like to death. And as on a plain four yoked stallions spring forward together beneath the strokes of the lash, and leaping on high swiftly accomplish their way, even so the stern of that ship leapt on high, and in her wake the dark wave of the loud-sounding sea foamed mightily, and she sped safely and surely on her way; not even the circling hawk, the swiftest of winged things, could have kept pace with her. Thus she sped on swiftly and clove the waves of the sea, bearing a man the peer of the gods in counsel, one who in time past had suffered many griefs at heart in passing through wars of men and the grievous waves; but now he slept in peace, forgetful of all that he had suffered. [13.63-92]

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The epics of Homer, c. 850 B.C., mark the beginning of a renaissance of Greek culture, after 300 years of a relative dark age. Homer describes the higher culture that had existed in the past, and inspires his listeners to colonize.

Odysseus Is Told: Organize Others!

There is one more important message of Homer to report, and this is the meaning of the final part of what the soul of prophet Tiresias, the wise man from Thebes, tells Odysseus in the underworld:

"Then there came up the spirit of the Theban Tiresias, bearing his golden staff in his hand, and he knew me and spoke to me: 'Son of Laertes, sprung from Zeus, Odysseus of many devices, what now, hapless man? Why hast thou left the light of the Sun and come hither to behold the dead and a region where is no joy? . . . Thou askest of thy honey-sweet return, glorious Odysseus, but this shall a god make grievous unto thee.

"'. . .[W]hen thou hast slain the wooers in thy halls, whether by guile or openly with the sharp sword, then do thou go forth, taking a shapely oar, until thou comest to men that know naught of the sea and eat not of food mingled with salt, aye, and they know naught of ships with purple cheeks, or of shapely oars that are as wings unto ships. And I will tell thee a sign right manifest, which will not escape thee. When another wayfarer, on meeting thee, shall say that thou hast a winnowing-fan on thy stout shoulder, then do thou fix in the earth thy shapely oar and make goodly offerings to lord Poseidon—a ram, and a bull, and a boar that mates with sows—and depart for thy home and offer sacred hecatombs to the immortal gods who hold broad heaven, to each one in due order. And death shall come to thee thyself far from the sea, a death so gentle, that shall lay thee low when thou art overcome with sleek old age, and thy people shall dwell in prosperity around thee. In this have I told thee sooth.'" [11.90-94, 100-101, and 119-136]

This struck me very much—Odysseus is told to become an organizer! If you want to organize people to go out to the sea and colonize, it is equally important to teach those deep in the landlocked countryside, what ships, sails, and oars are good for.

When Odysseus tells his wife, Penelope, during their first night together after 20 years, that he is supposed to leave once more to fulfill this final task, her answer is a happy one. Teresias, she says, foretold you happiness in your old age, while all people around us are happy and prosperous. Therefore, I am sure, everything will work out fine.

In this way, Homer inspired the Greek colonizers, Eratosthenes, and Maui; Eratosthenes inspired Toscanelli and Columbus; Humboldt and Schiller rediscovered and rehabilitated Columbus; and, today, these isochronic friends of ours are inspiring us, so that we can do our job and, in turn, inspire others.

Gabriele Liebig is the editor-in-chief of the German-language political weekly Neue Solidarität *(New Solidarity). This article is adapted from a speech she gave Nov. 22 at the winter conference of the Schiller Institute and International Caucus of Labor Committees in Germany, as part of a panel titled "What Is Real History As Science?"*

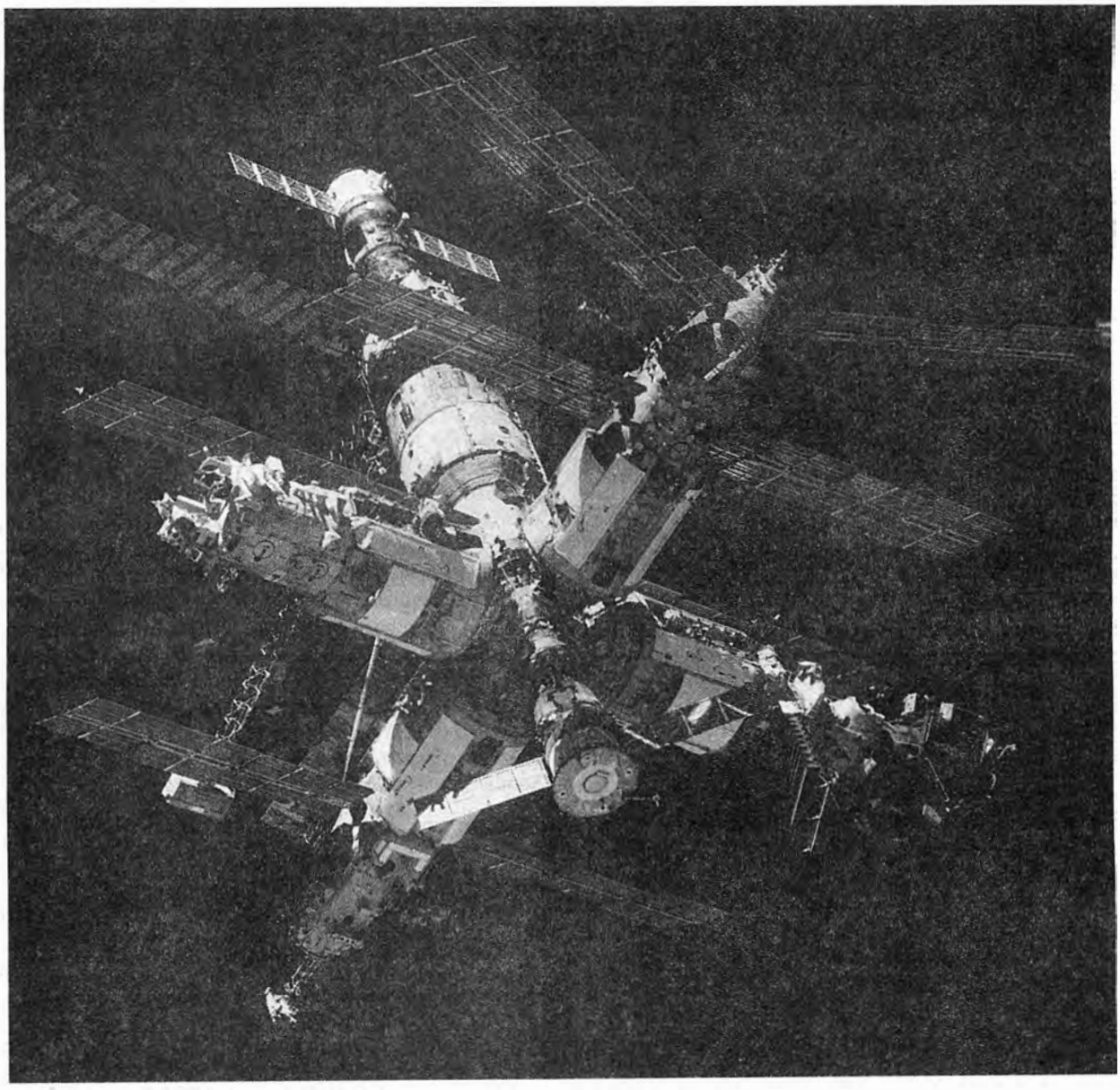
The passages from Homer's Odyssey *quoted here are from Harvard University's Loeb translation, as it appears on the website of the Perseus Project of Tufts University, and are reprinted by the permission of the publishers and the Loeb Classical Library from* Homer: The Odyssey, Vol. I and II, *translated by A.T. Murray; revised by George E. Dimock, Cambridge, Mass.: Harvard University Press, 1915, 1995. Line numbers follow each quotation in brackets.*

Notes

1. As emphasized by Lyndon H. LaRouche, Jr., in the introductory presentation at the conference. See p. 24.
2. The voyage of Rata and Maui in 232 B.C., as deciphered by Barry Fell, is described in "The Decipherment and Discovery of a Voyage to America in 232 B.C.," *21st Century*, Winter 1998-1999, p. 62. Other articles on the Egyptian voyage appeared in *Executive Intelligence Review*, Nov. 20, 1998.
   Fell's original writings on the voyage are published in various early issues of *The Epigraphic Society Occasional Publications.* For more information, contact the Epigraphic Society, Donal B. Buchanan, Secretary, 8216 Labbe Lane, Vienna, Va. 22182-5244, or e-mail donalb@aol.com.
3. LaRouche has discussed this concept in many recent writings, including the conference presentation that appears on p. 24.
4. Barry Fell, *America B.C.* (New York: Simon and Schuster, 1976).

The Mir Space Station: Man's Courage To Explore

by Marsha Freeman



NASA

Like great voyages throughout history, today's challenge to travel throughout the Solar System requires a great scientific plan, great resources—and may entail great risk.

When the first module of the Mir space station was launched into orbit by the Soviet Union on Feb. 20, 1986, the event was hardly noticed in the United States. The American public, and certainly the U.S. space agency, were still in a state of shock over the explosion of the Challenger Space Shuttle and the loss of seven astronauts, only one month earlier.

The secretive military Soviet space program had been launching space stations since 1971, without public notice or fanfare. And the U.S. space agency, NASA, had not had intimate contact with its Cold War rival for a decade, since the joint Apollo/Soyuz project had provided NASA's first peek into the closed Soviet program, in 1975.

But with that little-noticed launch, a new foothold was taking shape in space. Since Yuri Gagarin's first orbits of the Earth in 1961, American and Soviet astronauts had made brief forays into orbit, proving that man could survive space flight. Americans had landed on and visited the Moon, but with no long-term program to live there. The Soviets had deployed space stations before, but with limited capabilities and largely for military purposes, not as scientific outposts.

Over the course of a decade, the core module of Mir would become the anchor for a complex of scientific laboratories that the Soviets systematically would add to it. It became the world's first evolutionary space hardware that would grow in size and capability over its lifetime.

Over the 1980s, the Soviet Union was launching long-duration crews to Mir, and learning how to assemble, repair, and maintain spacecraft in orbit, so that man's presence in space could become virtually permanent. To service these craft, they were using the same families of expendable launch vehicles that they had developed for their military arsenal, decades earlier.

Meanwhile, the United States was developing the Space Shuttle, a reusable transportation system that could stay aloft for two weeks, and could bring astronauts, scientific equipment, and experiments to space and back *from* orbit. But as space planners often pointed out, the Shuttle needed a place to go *to*.

By historical accident, rather than design, the two manned space programs were developing capabilities that were complementary.

After the fall of the Soviet Union, and a period of internal dissent in the U.S. administration, a program of space cooperation was initiated in 1992, at the end of President Bush's term in office. The original Shuttle-Mir effort called for a Russian cosmonaut to fly on the Space Shuttle, and for an American astronaut to visit the Mir for three months. The Soviets had already flown foreign visitors to Mir from the East bloc and other politically allied nations, and also from Western Europe.

The fully assembled Mir space station, here photographed from the Space Shuttle, includes five scientific laboratories and docking ports for Soyuz transport ships and unmanned Progress supply ships.

When President Clinton came into office a few months later, the cooperative program was expanded, as part of the President's effort to strengthen America's relationship to the new Russian government, and to help preserve Russia's capabilities in science and engineering. The Shuttle-Mir missions became Phase I of a three-phase program that would culminate in the joint building of the International Space Station, which is now under way. This agreement was finalized in June 1994.

A program that started out as a political goodwill gesture is now a commitment to build and operate the International Space Station (ISS), a series of laboratories in space, with contributions by a dozen and a half nations, and the potential to open space exploration to all mankind. It is the stepping-stone in the future to leave Earth orbit, and to travel throughout the Solar System.

The International Space Station is the next step in the great project of exploration, which is similar in many ways to those from ancient times, through the Renaissance, to the conquering of the Earth's poles, the exploration of the American West, and the travels of all the explorers who circumnavigated the globe. The exploration of space requires no less the scientific plan, the courage, and the commitment of resources than did these previous epochs of discovery.

But in *this* age of exploration, there are no geographic limits: It is no less than the Solar System and the entire firmament mankind has admired, studied, and pondered since the time of the ancients, that is the object of our new creative efforts.

Mir As Historical Precedent

The challenge facing both the United States and Russia at the start of the Shuttle-Mir program was, how do you plan and execute a series of missions between two independent efforts that share no common language or culture and have little mutual trust, and where space experience, philosophy, and engineering approach have evolved so distinctly differently? It was well recognized by those involved that it would bode ill for the International Space Station if these problems could not be overcome during the Shuttle-Mir missions.

In his recent book, *Dragonfly: NASA and the Crisis Aboard Mir,* Bryan Burrough relates, largely through interviews with the participants, what the problems were that were faced by both the Americans and Russians in carrying out the joint program.[1] He documents in absorbing detail the crises on Mir, focussing on the fire and the collision with the Progress supply ship, both in 1997, and how they forced changes in the relationship between the two space powers.

Over the first two years of the program, Burrough documents, little went smoothly. However, the conclusion that should be drawn from Burrough's detailed description of the difficulties, is not that the program was a "failure," but rather, that the equipment breakdowns and the human flaws that

NASA

From the beginning of the Shuttle-Mir program, its success depended upon the working relationship between the Russian and American space travelers. Here, Shuttle Commander Robert "Hoot" Gibson (right) offers a smile and a handshake to Mir Commander Vladimir Dezhurov, during the first link-up of the two spacecraft, on June 29, 1995.

made the Shuttle-Mir program more difficult are universal problems—and have to be overcome.

For 15 years, NASA had trained astronauts to spend a week or two on the Space Shuttle. Their training was long, intense, and highly specific to the tasks they were to complete during a crammed schedule in space. Crew members did not have so much to "get along" with each other, as to closely follow orders from the mission's commander, and Mission Control in Houston, in order to accomplish as much as they could in a very limited amount of time.

Spending months aboard a space station requires a different outlook, both on the part of the crew members, and the people on the ground, where it is not possible to micro-manage every minute of the astronaut's time. To make the most of the long-duration mission, the crew must be able to be flexible and capable of changing its activities, especially when unexpected situations arise. It must work closely with Mission Control, which must also be flexible, in order to maximize what can be accomplished.

By the time the official documents were in place to begin the Shuttle-Mir program in June 1994, the first mission of a U.S. astronaut was already fast approaching, and there was little time left for adequate preparation. As a result, the March 1995 flight to Mir of Dr. Norm Thagard suffered from his having had too little training, language difficulties, and a U.S. space agency that had little idea of how to service and support its crew member during a long-duration flight.

In addition to the objective obstacles, *Dragonfly* author Bryan Burrough details at length the personality weaknesses that limited the effectiveness of some of the long-term astronaut missions on Mir. Medical doctor Norm Thagard, he reports, "had a reputation as a grump," and was known as "a bit of a whiner." Shuttle Commander John Blaha, Burrough says, was very dependent on his relationship with his wife, and became depressed as the load of experiments he was expected to complete on Mir became impossible to keep up with. Jerry Linenger, on board Mir when the fire broke out in February 1997, had a "reputation as a complainer," says Burrough, was quick to anger, and was "fiercely independent," at a time when the crisis required teamwork.

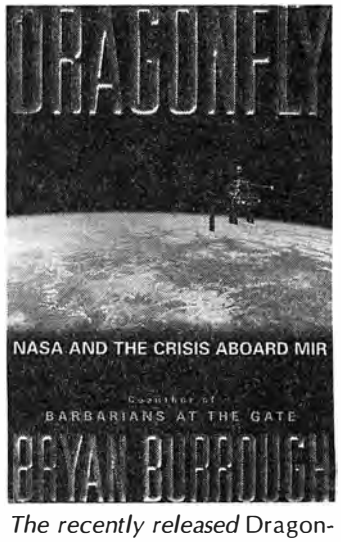
All three astronauts left the space program after their experiences on Mir. NASA learned that the strengths, such as self confidence, "over-achievement," and concern about one's career, which have made the Space Shuttle program a resounding human success, are not necessarily optimal character traits for successful long-duration missions.

The other four Mir astronauts, who were able to carry out their missions and perform more in line with their abilities—Shannon Lucid, David Wolf, Michael Foale, and Andy Thomas—decided before their flights that they had to be flexible in their approach, develop close working relationships with their fellow cosmonauts, and see themselves as part of a team.

Another valuable lesson learned was about the level of performance necessary by the technical and managerial people supporting the crew on the ground. Norm Thagard felt "abandoned" by a Mission Control that did not provide enough technical or psychological support. Jerry Linenger felt so "misunderstood" by NASA Mission Control support personnel, that for one period on Mir, he refused to talk to ground controllers.

To put things in perspective, it should be pointed out that these were not the first instances of a serious "disconnect" between the crew and Mission Control. During the third and last long-duration stay on the American Skylab station at the end of 1973, the crew, which felt overworked, went on a one-day "work stoppage" to register its complaints to the ground controllers. There is a fine line between giving guidance and assistance to the crew, and placing unrealistic demands upon them.

Every astronaut who flies in space, military or civilian, is a volunteer. When it came time to choose astronauts to spend months on the Mir, and a year training in Russia, NASA asked for volunteers. Considering the hardship of training for a year in a foreign country, and then spending months in orbit away from family and friends, it is probably not accidental that of the seven NASA volunteers, three were in their 50s, without small children at home, and two were bachelors. In addition to the time spent away from home, the astronauts knew that their accommodations in Russia would be more like "camping out," than the standard of living they were accustomed to in Houston.



The recently released Dragonfly *has created a storm of indignation with its criticisms of the Russian and U.S. space agencies.*

And their Russian counterparts? Although the Russians psychologically screen their cosmonauts before they send them into space for months at a time—which NASA did not do—they have not been spared their share of personality conflicts between crew members, or

NASA

The first life-threatening crisis on Mir was during Jerry Linenger's stay there, when a fire broke out in February 1997. In this Jan. 21 photo, Linenger is in the central base block of Mir. Note the photos on the wall of the first man in space, Yuri Gagarin, and of space theoretician Konstantin Tsiolkovsky. At right rear is Soviet "chief designer" Sergei Korolev.

antagonisms between the isolated orbiting crews and the program managers on the ground. The reaction of the various cosmonauts to their different American crew members covered the entire range of human interaction, from hostility, to jealousy, to genuine friendship.

'A Great Leap Forward'

For the space agency as a whole, Frank Culbertson, Shuttle-Mir program director and astronaut, argues that the most important lesson NASA—and perhaps also the Russians—learned was humility. "We learned that we don't know everything about space flight. As good as we are, we learned things we did not know. Just setting the bit in your mind that you don't have all the answers, as an agency, or a country—that someone else has something to offer—that was a great leap forward."

It is important to remember that U.S. astronauts were not the first guests on Mir. As Culbertson explained during testimony to the House Committee on Science in September 1996, "Initially, the role of the U.S. crew was patterned after that of the other foreign personnel, to fly to the Mir as guest cosmonauts."

The Russians, who, like the Americans, have had unchallenged control over their manned space program, without interference (or squeamishness) from the countries of guest cosmonauts, surely were not going to readily share what they consider the pride of their independently developed space technology with their former Cold War competitors.

Burrough repeats throughout his book the charge that NASA relegated its well-known focus on safety to its Russian partner during the Mir missions, leaving its astronauts to the vagaries of frequently overly demanding, if not irresponsible, Russian space program managers, as Burrough characterizes them.

Culbertson explained to Burrough that the NASA contract with the Russian Space Agency stipulated that Russia would guarantee the safety of our astronauts on Mir, and we, their cosmonauts who flew on the Space Shuttle. "Would NASA let Russians stand about Mission Control [in Houston] second-guessing Shuttle flights? Of course not," Culbertson said.

After the fire and collision, that relationship changed, as NASA became a partner with the Russian Space Agency on the Mir, not a guest. Indeed, it was not *in spite of* but *because of* the crises on Mir, that trust was developed between the people in the two space programs.

The International Space Station will have not only Russians and Americans on board, but citizens of many different nations. The lessons learned from the Shuttle-Mir program have added insight about the interpersonal situations facing long-duration crews, and the strengths within themselves that crew members would best be able to drawn upon.

The Crises on Mir

On Feb. 23, 1997, a fire broke out on the Mir space station, as the crew was activating an oxygen-producing canister. There are discrepancies among the crew members' descriptions of the length, extent, and seriousness of the fire, which Burrough reports from his interviews. One clear result of the fire, however, was that the event seriously traumatized astronaut Jerry Linenger. On May 16, the Space Shuttle Atlantis, commanded by Charlie Precourt, docked with the Mir, to return Linenger to Earth and deliver astronaut Mike Foale to the station. Linenger opposed Foale's staying on the Mir, saying that he did not think it was safe.

Shuttle Commander Precourt was asked by NASA managers to assess Linenger's state of mind as they docked with Mir. "[Linenger] sounds like what he is, a rookie," Precourt reported. Later, he told Bryan Burrough: "You know, I've been around fighter jets and spacecraft for 25 years, and these things just happen. You have a fire in your engine and you just don't quit. You fix it and go on. You just go on."

Mir's troubles were far from over. On June 25, an unmanned Progress supply ship collided with the Spektr module of the Mir station, as commander Vasily Tsibliyev was trying to perform an experiment with a new docking procedure, required by Mission Control. The Spektr module, containing the bulk of Mike Foale's scientific experiments and all of his personal effects, was punctured and depressurized.

Russia's Real Problem As a Space Power

Since the problems on Mir in 1997, there has been a chorus of voices in Congress, among space commentators such as writer Jim Oberg, and among gossip circles on the Internet, calling for an end to U.S.-Russian space cooperation. The Russians will never fulfill their commitments to the International Space Station, it is said, and in their wily way, the Russians are simply trying to pry more money out of the U.S. space agency.

However, if the Russian Space Agency is receiving half the actually *inadequate* amount it is promised in the annual budget, where does the blame lie?

Economic policy decisions in Russia, after the fall of the Soviet Union, have been made by a handful of 40-something "reformers," allied with international financiers, and Chernomyrdin partner Vice President Al Gore. These "reformers" have sold off the nation's precious industrial and technical enterprises, and indebted Russia to the International Monetary Fund, creating massive unemployment and plumetting life expectancies throughout the population. The monies from privatizations of national enterprises and from loans have funded criminal activities and been used to amass personal fortunes.

After six years of devolution of the world's only other superpower, the new government of Prime Minister Yevgeny Primakov has vowed to overturn the self-destructive policy Russia has followed since 1992. On Feb. 5, Prime Minister Primakov told the Russian Duma, the lower house of Parliament, that the budget for this year starts a new policy. A Russian Development Bank will be created, to restart investment into the physical economy of the nation.

Primakov said,

> The question was raised here of the need to support science. We are very well aware that without it we cannot move forward. . . . [W]e won't be able to achieve anything without introducing scientific results and new technologies, so as not only to bring back the time when Russia set the pace of fundamental research, but also to ensure that these achievements in the field of fundamental research should be translated into achievements of applied sciences, and should be applied in production.

Those who worry that Russia will not meet its commitments to the International Space Station would do better to organize support from the White House and the Congress for this sane turn in economic policy in Russia. That is the only hope for the Russian space program.

—Marsha Freeman

Quick thinking by the crew saved the station, as the Spektr module was isolated from the rest of the Mir. Doing this by closing the hatch, however, cut the power lines from Spektr's solar arrays to the rest of the station, throwing the crew into darkness, and shutting down nearly all of Mir's on-board systems.

Surely, Mike Foale could have panicked, or sulked, blaming the Russian commander for the accident. Instead, he came up with a plan to help regain the space station's capabilities. More important, he realized that the camaraderie he had established with his Russian crewmates through his previous weeks on Mir would be critical to getting them through this crisis.

Before the collision, Burrough relates, Foale had set up an impromptu theater in the Spektr module. Every Saturday night he selected an American film for all of them to watch on a computer monitor. As there were no Russian subtitles, Foale did a "running translation, complete with voices," according to Burrough.

The theater and most of the movies were destroyed in the collision. Both Foale and crewmate Aleksander Lazutkin realized that the commander blamed himself for the accident, and they decided to try to resurrect the Saturday night movie tradition to raise his spirits. So, on the Saturday night after the collision, when "enough power has returned to the station . . . Commander Tsibliyev decides it is time for all three men to take a much-needed rest," Burrough reports. Foale selected the

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Astronaut Shannon Lucid spent much of her time on Mir without the scientific experiments she was supposed to carry out. But her good nature and sense of humor made her increment on the station a productive one. Here, she is training on a mock-up of the Soyuz vehicle.

film *Apollo 13* for them to watch. Tsibliyev later recalled, "That film, it is the best of the best. . . . Everything in the film is so realistic, so truthful, so dramatic, it's just perfect."

Afterwards, all three men agreed that their circumstances were far less dangerous than those of the Apollo 13 astronauts. "We felt that, especially from a psychological point of view, their situation was much worse than ours," remarked Tsibliyev. "We at least had a spaceship [the Soyuz, docked at all times to the Mir] that could get us home. With Apollo 13 they had to fly all the way around the Moon in order to get back to Earth."

Later in the mission, Mike Foale received via e-mail a copy of an article that the Apollo 13 commander, Jim Lovell, had written comparing the two flights. "Jim said that 'I understand how these guys feel up there, because I've been there as well. I know their courage and bravery.' It was quite wonderful to hear that from Jim," Tsiblyev recalled.

The Russians and the Americans had distinctly different reactions to the collision aboard Mir. Burrough reports that NASA Phase I leader Frank Culbertson, and his deputy Jim Van Laak, both thought the joint program was finished. "They were ready to give up."

The Russian response was summed up by former cosmonaut and Russian Phase I director Valery Ryumin: "You have to remember, we've been operating this station for a long time, and believe it or not, we've had a lot of abnormal situations. Our guys are simply tougher than the Americans in these situations."

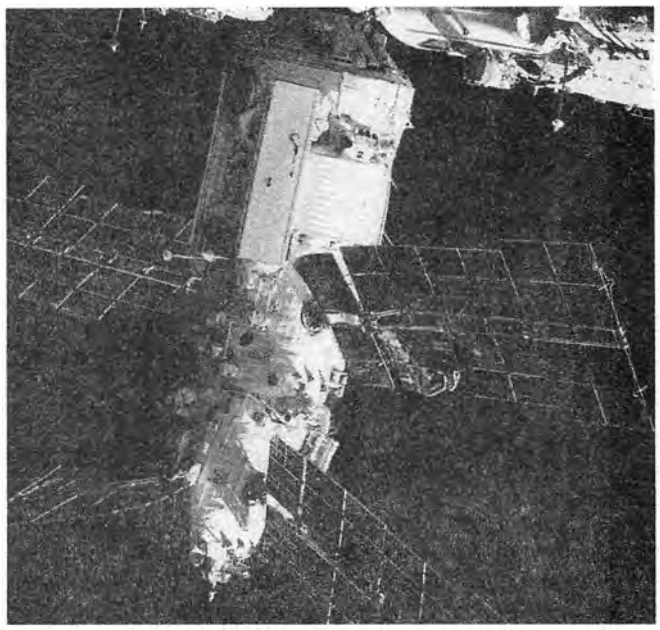
Crises aboard Russian space stations were nothing new with the Mir. In February 1985, a year before the first module of Mir was launched, the Russian ground controllers had lost contact with the predecessor Salyut 7 space station. Without ground control, the solar arrays were not pointed at the Sun, and the electrical power was lost. The station was frozen inside and slowly tumbling.

On June 6, cosmonauts Vladimir Dzhanibekov and Viktor Savinykh were launched into space, in order to assess the situation on Salyut 7, arriving at the station two days later. The official flight plan called for the cosmonauts to retreat to the Soyuz vehicle and return to Earth if there were no power on the station. But the cosmonauts were not about to abandon the station that easily.

For several days, the crew made repairs to the Salyut 7, slowing bringing it back to life. The temperature inside was estimated at −10° Celsius. Because the thermometer's lower range went down only to 0°C, Mission Control had one of the crew members spit on the wall and time how long it took the saliva to freeze, in order to estimate the temperature.

The crew worked in arctic attire and reported that their feet got painfully cold. After being in the Salyut without ventilation (no fans were running), they reported that they had headaches and felt listless and sleepy from the buildup of the carbon dioxide they were exhaling. They had to go back to their Soyuz spacecraft every 40 minutes to get warm. On June 12, they were finally able to activate the life support systems on the Salyut. It took the cosmonauts 10 days in all to bring the station up to a condition in which mission planners would permit an indefinite stay aboard.

In referring to this incident, *Dragonfly* author Bryan Burrough states that the experience with Salyut 7 in June 1985 showed that the Russians could "almost literally bring a space



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During Mike Foale's stay on Mir, an unmanned Progress supply ship collided with the solar arrays and a radiator on the Spektr module. Some of the damage can be seen here; note the crumpled section on the right-hand solar array.

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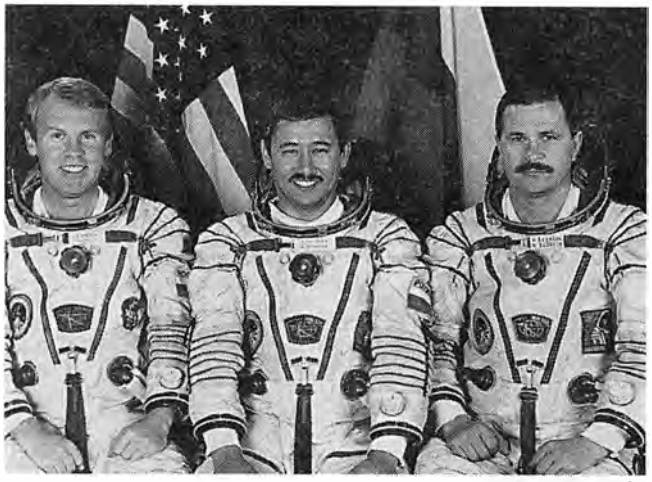
The supply ship collision created a political debate over whether astronaut David Wolf, here suiting up for his trip, should take Mike Foale's place on Mir. Wolf successfully completed his increment on the Russian station.



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Andy Thomas, (left) the last NASA astronaut to live on the Mir, is seen here in Russia with his crewmates Talgat Musabayev (center) and Nikolai Budarin. In February 1999, Thomas received a state award from the government of Kazakhstan for his work on scientific experiments done aboard Mir for nations of the former Soviet Union.

station back from the dead." On the other side of the Atlantic, however, he reports:

> Despite two years of work aboard Mir, the Americans remained largely ignorant of the practical realities of long-duration space flight. When there was a mechanical breakdown aboard a Shuttle, the mission was simply ended, and repairs were performed later on the ground.
>
> The Russian space stations, of course, never had this luxury. When something went wrong aboard Mir, cosmonauts were forced to fix it in space, which had given the Russians 20 years' experience in the kind of seat-of-the-pants repairs the Americans had only read about in books. While NASA tended to study and diagram things to death, the Russians had developed the skills needed to fix things on the run.

The collision aboard Mir caused a crisis in the U.S. space agency, and became a political football for the Republican majority in the U.S. Congress. A decision had to be made as to whether it was safe enough to send the next astronaut, David Wolf, to Mir. The Congress called for "independent" safety assessments to be made.

One person called upon to evaluate the safety of the Mir, was Ronald Merrell, a Yale University physician and a member of former astronaut Gen. Tom Stafford's team. In a telling statement, Merrell stated after his investigation: "I thought Mir was as safe as it had ever been. I really felt quite confident that the biggest danger to the crew had been human behavior and not the age of the craft."

The Russians tried to understand the political flap in the United States over the David Wolf flight. (House Science Committee chairman James Sensenbrenner, a Wisconsin Republican, had threatened Administrator Dan Goldin that it would be the end of his career, should anything happen to Wolf.) Russian deputy flight director Viktor Blagov told Burrough,

> If I were them [the Americans on the review team] I would do the same thing. . . . *We* didn't have any doubts, we proved it to them, and they left. We can understand their concern about safety. On the other hand, you can't just go around and scare yourself like this all the time. We have an expression in Russia: 'You can't be a like a bird scared of a bush.' Once a bird gets scared, he is afraid of everything. If you get scared, you should not be working in space. Space presents some danger. There is risk. If you are scared, you should go do something safe, like cleaning streets.

Two Kinds of Courage

Ultimately, the decision of whether to send David Wolf to Mir lay at the feet of Administrator Goldin. On Sept. 24, 1997, Goldin made the decision to continue the Shuttle-Mir program. At a press conference in Washington that day, Goldin called upon the American people to return to the spirit of exploration that had been the foundation of this nation. He said:

> It is only after carefully reviewing the facts, thoroughly assessing the input from independent evaluators, and measuring the weighty responsibility that NASA bears for the lives of our astronauts, that I approve the decision to continue with the next phase of the Shuttle-Mir program.
>
> This is a decision that all of us at NASA do not take lightly. . . . I will not trivialize the risk associated with human space flight and exploration. Like all Americans, I know every time an astronaut travels into space there is risk. When we build the International Space Station, we will encounter similar problems and there will be danger. But NASA is ready. We are ready because the review assures us. But we're also ready because it's the right thing to do. We overcome the unexpected. We discover the unknown. That's been our history, and that's been America's destiny.

At a luncheon during the annual meeting of the American Astronautical Society in Houston on Nov. 17, 1998, the man in question, astronaut David Wolf, observed,

> It is easy to cooperate when things are going well. The test is when it's difficult. . . . There was a lot of fortitude in the leadership [of NASA] to say it was safe, when there are inherent risks. This is exactly what the American people want us to do, this program. . . . [T]here is [only] a vocal minority of critics.

At the same meeting, Jim Van Laak summarized how each astronaut aboard Mir had to deal with something he had never seen before he went. He said that the collision during Mike Foale's increment on Mir was a:

> pivotal moment in the program. Everything was up to the crew, which did a magnificent job. It was clear the future of the program was on the line.
>
> Courage comes in several forms. One is in the short term, like the fire and collision. Another courage is

NASA

Man will explore space because it is the frontier of new knowledge. And no matter how risky, he will build and use the machines and tools he needs to bring him there.

> We learned how to work with the Russians, we learned how to do a science program on a space station like that. We learned all about the human factors, and we learned how to get the Shuttle up and back. We learned about the [crew] support structures needed on the ground, and the psychological support and technical support. And so, it was not coincidental that my increment [aboard Mir] went very smoothly.

Andy Thomas is now working as part of a team of astronauts applying the lessons learned from the Shuttle-Mir program to the International Space Station. Currently, he is assisting with the training in Russia of astronauts who will work on the ISS and must be familiar with Russian hardware, including the Soyuz capsule that would bring a crew back in case of an emergency.

He said in his interview, "I do think it would have been inconceivable to try to do a collaborative space station with the Russians, without having done the Shuttle-Mir program."

To those who carped that the Apollo program of the 1960s to land men on the Moon had not "produced" anything of value, Apollo 11 astronaut Michael Collins responded that if the Apollo program had only brought back a few pounds of rocks from the Moon, it would have been well worth the effort, because it mobilized the resources and the spirit of a nation, and laid the basis to open the frontier of space.

Similarly, had there been nothing accomplished aboard the Mir during the three years that astronauts lived there, other than laying the foundation for the International Space Station, it would have been well worth the effort, the resources, and the risk.

Marsha Freeman is an associate editor of 21st Century *magazine, and the author of* How We Got to the Moon: The Story of the German Space Pioneers, *published by 21st Century Science Associates.*

> putting one foot in front of another every day. [We will see] if there is the American courage to tough it out.

Courage in the face of danger for its own sake is foolishness. The courage to carry out a plan that forces one to make new discoveries is the characteristic of human history that has led to the progress of human civilization.

In a recent interview with Andy Thomas, the last NASA astronaut to live aboard Mir, I observed that his increment on the Russian station was much less "eventful" than the fire during Jerry Linenger's mission, or the collision on Mike Foale's. Thomas replied,

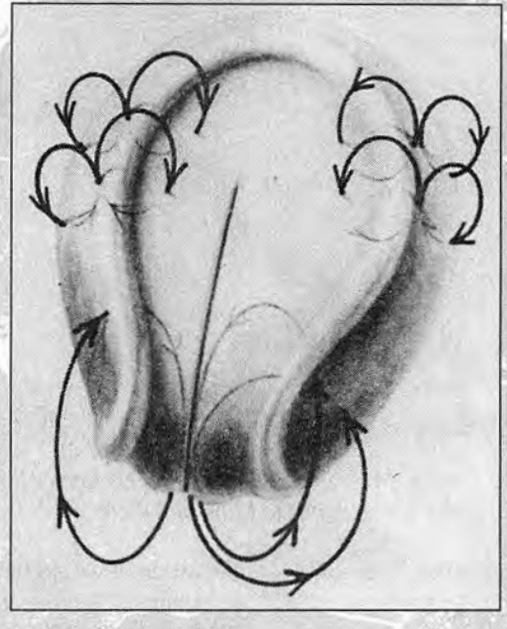
> The reason why it was a lot less eventful, was because of the experience that was gained in the flights of my predecessors.

Notes

1. *Dragonfly: NASA and the Crisis Aboard Mir*, by Bryan Burrough (New York: HarperCollins, 1998), hardcover, 528 pages, $26.95.

THE ELECTRIC EMBRYO

How Electric Fields Mold the Embryo's Growth Pattern And Shape



by Colin Lowry

Contrary to the prevailing view in biology today, embryonic development is controlled by electric fields, whose very existence is ignored by the molecular reductionists.

Background: Selected stages in the embryonic development of the axolotl. Foreground: Schematic of ionic currents traversing early amphibian embryo.

In the early 1970s, biophysicist Lionel Jaffe was pondering the question of how an embryo creates the body axis which determines the head from the tail, or the top from the bottom. The single-cell embryo appears to be symmetrical. As it develops, the embryo must create asymmetries and singularities leading to a body plan, and eventually to the formation of specialized cell types. How does the embryo establish its own polarity? These important questions guided the scientists of the 19th century in their investigations into the organization of living systems, but have been largely ignored in the 20th century.

Working at Purdue University, Jaffe was studying the fertilized eggs of the seaweed-like plant known as fucus to try to answer these questions. Fucus, unlike many animal species, does not have a pre-set axis in the egg, and does not create the first axis until after fertilization. Jaffe was steeped in the literature and experiments having to do with electric potentials and living systems going back into the 19th century. He recalled that in the 1920s, Elmer Lund had done experiments with fucus, and found that external factors influence the creation of the body axis. Normally, exposure to light can set the direction of the body axis in fucus, resulting in an unequal first cell division. Lund also grew fucus embryos in the dark, and by applying a weak electric current through the surrounding water, found that this current could also set the body axis.

Thinking through Lund's result, Jaffe wondered if the fucus embryos themselves created an electrical current which could establish a polarity and set the body axis. He then designed a series of experiments to test the hypothesis that the embryos created electric currents that flowed in and around themselves. To be able to measure the strength and direction of these electric currents, Jaffe and his student, Richard Nuccitelli, developed an ultrasensitive vibrating-tip microprobe in 1974. With the new probe, Jaffe measured minute ionic currents flowing in the aqueous medium around the fucus embryos, and found that these currents were driven in a loop through the embryos, establishing the body axis.

Jaffe's results re-opened investigations into electric fields in directing embryonic development, and the related process of limb regeneration. Now, armed with superior modern equipment for measuring bioelectric currents, Jaffe's students could attempt to answer questions about how electric fields could influence cell migration, wound healing, and pattern formation in the embryo, and how cells could "know" their position within an embryo. This approach was in direct opposition to the radical reductionist views that were increasingly dominating biology at that time—and still do today. Instrumental in Jaffe's unique ability to design these crucial experiments were his intellectual roots in the works of the early 20th century biologists, which remain mostly unknown to scientists today.

Two scientists, Richard Borgens and Kenneth Robinson, who were graduate students at Purdue University trained by Jaffe, have continued and expanded the investigations into electric fields and living processes up to the present day. Borgens and Robinson were part of a closely knit group of students who matured as researchers in a scientific culture very different from that found today.

With Jaffe as their mentor, there was a strong emphasis on the historical issues of science. Jaffe kept the fundamental questions in embryology of the 19th and early 20th century fresh in the minds of his students. The students were required to learn the history of science, and the contributions and crucial experiments of individual scientists stretching back to the 19th century. Three times a week the students would meet as a group with Jaffe and his colleague Joseph Vanable, to discuss projects that were ongoing in the laboratory. Richard Borgens described the importance of these meetings in providing a "cross-fertilization of ideas," which influenced his own scientific approach.

Do Currents Control Limb Regeneration?

Richard Borgens had come to Jaffe's laboratory with an established interest in limb formation during development. He had done his master's degree project on the formation of the bones of the limb in the embryonic chick. Limb development in the embryo has many features in common with limb regeneration in adult amphibians. After the development of the vibrating tip probe, the first thing Borgens examined, using this new tool, was the process of limb regeneration in adult salamanders.

Experiments from the early 1940s had shown that there are electrical changes at the surface of the limb after amputation in regenerating amphibians. In the first experiments in 1977, Borgens found that an immediate response to amputation of the limb in salamanders was the production of an intense electric current, driven out of the tip of the limb stump. This current followed a path out of the stump tip, and returned in a loop through the water, or the moisture on the skin, to the undamaged area of the limb behind the amputation. The density of the current ranged from 20 to more than 100 micro-amps (μA) per square centimeter just after amputation, and fell steadily over time to a level of just a few $\mu A/cm^2$ within a few days.

The decrease in the current flowing out from the stump coincides with the formation of the wound epithelium (skin), which creates increased resistance in the circuit path. All of the animals that naturally regenerate their limbs as adults, which includes newts, salamanders, and axolotls (all members of the urodele order, tailed amphibians) produce a strong electric current running through the tip of the amputated limb stump.

What is known to occur at the cellular level during regeneration? After amputation, the wound surface of the limb is covered by a thin wound epithelium in a matter of hours. Beneath this wound epithelium, cellular debris is transported away, and uninjured cells begin the process of de-differentiation. These cells lose their specific characteristics that identify them as muscle, bone, or cartilage cells, and transform themselves into a mesenchyme-like cell, called a blastemal cell. These blastemal cells have properties similar to embryonic cells, in that they can differentiate into any cell type. It is this group of cells, known as the blastema, that will grow and form the regenerating limb.

Experiments have shown that two tissues are essential for the initiation and control of limb regeneration. First, limb regeneration requires the formation of a wound epithelium, and cannot proceed in the absence of it. Also, the wound epithelium gives a directionality to the outgrowth of the blastemal cells below it. If the wound epithelium is surgically moved, and placed in an eccentric position upon the stump, the regenerating limb will grow in this new direction.

The second essential tissue for regeneration is the presence of intact peripheral nerves. If the nerves leading into a regener-

ating limb are removed, no regeneration can proceed. The dependence on the presence of nervous tissue has led to the search for growth factors produced by nerve cells that could help explain this phenomenon. So far, many growth factors have been identified, but none of them can substitute for the presence of the intact nerve in the limb stump.

More Questions

The electric currents that Borgens had measured at the stump tip raised several questions. What was responsible for generating this current? Did the current and the resulting electric field influence the behavior of the cells involved in regeneration? Borgens set out to find the source and the character of the electric current. It was well known that skin in amphibians and all other vertebrates produces a voltage difference across its surface. This "skin battery" maintains an inwardly positive potential ranging from 40 to 80 millivolts by actively transporting sodium ions (Na+) and other positively charged ions from outside to inside. Because the epithelial cells are themselves polarized in structure, and are tightly joined, they create a resistant barrier to the flow of positive ions in the opposite direction. However, any break in the epithelium would create a low-resistance pathway, leading to the immediate flow of positively charged ions outward.

To see if the skin battery was responsible for the generation of the currents leaving the limb stump, Borgens manipulated the concentration of sodium ions in the pond water surrounding salamanders. When the sodium ion concentration was increased five-fold, the currents that were measured leaving the limb stump were also found to increase approximately five-fold. If the salamanders were kept in water that was deficient in sodium, the stump currents were found to be reduced by 90 percent. These effects could be reversed by returning the animal to normal pond water.

Now that the currents leaving the limb stump in salamanders had been roughly defined, Jaffe, Borgens, and Vanable were curious to see if the application of these electric fields upon a non-regenerating amphibian, (anurans) such as the frog, could induce limb regeneration. They chose the grassfrog (genus *Rana*), and constructed an electric stimulator which could be implanted under the skin of the back, with two electrodes emanating from it. In one group of animals, the negative electrode was routed through the core tissues of the limb stump, with the uninsulated portion in contact with the stump tip tissue. The positive electrode was implanted beneath the skin of the back. This setup matches the polarity of the current flow that was measured in the salamander. In the second experimental group, the electrodes were reversed, with the positive electrode routed into the limb stump tip. A control group had electrodes implanted with an inactive electric stimulator.

The results in the control group of grassfrogs showed no regenerative response, with the limb stump healed over with thick skin and scar tissue. However, after weeks of stimulation with the negative electrode at the stump tip, the second group of animals showed varying degrees of regeneration of the limb. These limbs were abnormal in their external appearance, and upon examination their internal tissues were disorganized and undifferentiated. This was a striking result, even though the regenerated limbs were incomplete and hypomorphic. The third group of animals, which had a positive electrode implanted at the stump tip, resulted in the degeneration of the stump tip tissues, and no regenerative response. These experiments demonstrated that by artificially imposing electric currents of the same polarity and similar field intensity as found in the salamander, regeneration could be initiated in the normally non-regenerative adult frog.

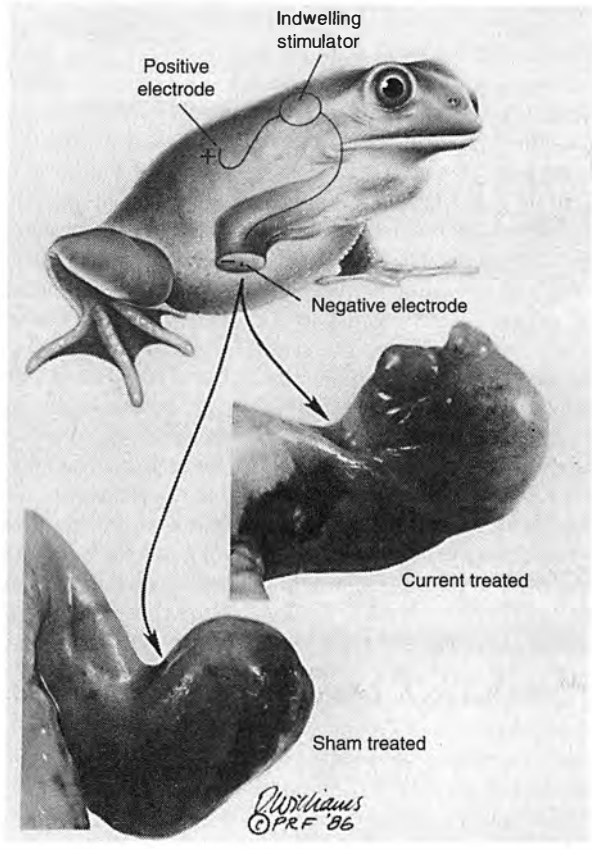


Figure 1
ELECTRICAL STIMULATION OF FORELIMB REGENERATION IN ADULT FROGS

The negative electrode is routed into the limb stump tip, and the positive electrode under the skin of the back, as depicted in the drawing of the frog. The photographs below show actual responses of current-treated and sham-treated limbs. The arrows point to the plane of amputation in the limbs.

Source: R. Borgens, *J. Exp. Zool.*, Vol. 200, pp. 403-416, 1977. Reprinted by permission of Wiley-Liss, Inc.

Experiments with Frogs after Amputation

The initial experiments were followed up two years later, in 1979, with an examination of the currents in non-regenerating frogs after amputation. Although frogs (anurans) and salamanders (urodeles) are closely related, there are differences in the anatomy of their limbs which may help to explain why adult frogs do not normally regenerate. Frog larvae are able to regenerate portions of their tails and limbs until the stage in metamorphosis when the subepidermal lymph spaces begin to develop in the limbs. This subepidermal lymph space in the adult frog limb could act as a low-resistance pathway for shunting

Vincent P. Walter, Purdue University

Dr. Richard Borgens and a student working in his laboratory at Purdue University. Borgens is using the microscope to photograph specimens.

current generated by the skin battery away from the core tissues of the limb stump. Salamanders and other urodeles do not have this subepidermal lymph space.

Borgens measured the stump currents in adult frogs, and found that the highest density of current was found leaving the subepidermal lymph space. The current running through the core tissues was found to be four to five times lower in intensity than those in the lymph space. Also, the peak currents leaving the stumps of adult frogs were weaker than those found in newts. These differences suggested that the lack of sufficient electrical currents running through the core tissues of the limb, the area which gives rise to the blastemal cells, results in diminished regenerative ability.

Because the adult frog does produce a stump current, if the topography of the current could be made similar to the urodele, perhaps regeneration in the adult frog would be more complete. Borgens refined the experiment using electrical stimulators in frogs, this time using the African clawed frog *Xenopus laevis*. *Xenopus* is known to naturally produce a minor regenerative response to amputation, which usually consists of a short spike of cartilage covered by skin. Using internally implanted electric stimulators, with the negative electrodes running through the core tissue of the limb stump, Borgens observed that, after two months, these animals had grown limbs that were similar to the "paddle" stage of limb found in salamanders before the digits form.

The control group of animals had spikes of cartilage surrounded by skin typical of the natural response. Curiously, many of the electrically treated limbs appeared almost normal, externally, but the internal structure was quite disorganized and abnormal. These regenerative structures were called "pseudolimbs," and had large amounts of nervous tissue running through the cartilage in a disorganized pattern.

The conventional understanding of developing limbs is that the internal cellular organization determines the external form. However, the pseudolimbs are a challenge to this notion, and point to the importance of electric fields in determining morphology.

In his next experiments, also in 1979, Borgens examined what the effect of specifically blocking the sodium ion channels of the skin would have on regeneration in salamanders. He had shown previously that the stump currents seemed to depend on sodium ions as their charge carrier. Salamanders and newts had their forelimb stumps treated daily with the sodium channel blocker amiloride. At first, all of the treated animals were blocked from regenerating their limbs, but after a period of time about half of the animals began to regenerate. Measurements of currents emanating from the stump tips in these animals showed that they indeed generated strong currents in the absence of sodium.

Amazingly, some of the animals which had been inhibited from regenerating for weeks by the amiloride treatment, recovered and began to regrow their limbs at a greatly accelerated rate. This was a startling result, which again brought up new questions. When these animals were examined during the period of inhibition, their limb stumps were covered by full thickness skin, and scar tissue, which is indicative of non-regenerating species or permanently arrested regeneration. However, these animals escaped this inhibition, and then regrew at accelerated rates, sometimes producing limbs that were more fully developed than those of the control animals.

Was there something building up in the inhibited limb stumps that produced this accelerated growth? This question could not be answered by the experiments then, and remains a mystery today. However, the fact that salamanders and newts could produce stump currents after recovering from the inhibition, meant that these animals had adapted by using other positively charged ions, such as calcium and potassium, when the sodium channels were blocked. In later experiments, it was shown that if the animals were kept in an environment that lacked calcium, potassium, and sodium, stump currents could not be generated and regeneration was blocked.

Field Model of Regeneration

Borgens's experiments leave no doubt as to the importance of the electric field in initiating and controlling regeneration. But what are the targets of this field? What are some of the possible effects an electric field produces in cells? We know from earlier experiments that the nerves and the wound epithelium are the two crucial tissues required for regeneration to occur, so could these be targets of the electric field?

From experimental measurement, the electric field is strongest at the wound epithelium, where the current flows out from the limb stump. The flow of current establishes polarity in

the limb, and creates voltage gradients, which could provide cells with a way of sensing their position. Also, the current flow provides a directionality for the cells to grow outward. Electric fields have been shown to influence the direction of cell migration, so this could also be one of its effects in the developing limb.

From the experimental results, it seems that the immediate flow of current after amputation is crucial in initiating the regenerative response. Thinking about this problem from the standpoint of responses to injury, the first thing that changes after injury to the skin, or to the membrane of a single cell, is a flow of electric current. Cells must have evolved injury responses that detect this current flow as a signal, which initiates the healing process. In the case of amphibian regeneration, the de-differentiation of cells in the blastema may be a result, directly or indirectly, of the current flowing out of the limb stump.

The other primary target of the electric field, logically, is the nervous tissue, which is required for regeneration to proceed. *In vitro* experiments have shown that neurons grown in culture will extend and grow neurites (precursors to axons and dendrites) preferentially toward the cathode (negative pole) in an electric field. Given the formation of the pseudolimb in the adult frogs, it is curious that so much of the internal tissue was nerve. With the negative electrode at the stump tip in the frog, a hypomorphic regeneration proceeds, and the polarity of the applied field is the same as that which neurites grow toward in culture.

Borgens suggests that the field polarity helps to direct peripheral nerve regrowth into the limb stump, which supports limb regeneration. However, the situation in the regenerating limb with regards to the relationship between the nerves and the wound epithelium still leaves many questions unanswered. How does the field coordinate the actions of these two essential tissues during regeneration? Do the cells of the regenerating limb grow according to a global electric field, which has already defined the shape and orientation of the limb? To address this tantalizing question, Borgens directed his next experiments to the process of limb formation in the embryo.

Does the Embryo Use Fields to Drive Its Development?

Richard Borgens's interest in embryonic limb development overlapped with the work of his friend and colleague Kenneth Robinson. In 1983, they both published research papers on the role of the electric field in predicting the location of the emerging limb bud in two different animal embryos. Dr. Robinson had been studying the effects of electric fields on the growth and behavior of cells for several years. Robinson was Lionel Jaffe's first graduate student, and was interested in discovering how electric fields in an embryo might control the behavior of cells.

The experimental history of electric fields and their influence upon cells, especially neurons, left the issue unresolved between claims of the fields guiding nerve growth, and a complete denial of any effect on nerve growth. Robinson was aware of the work of S. Ingvar in 1920, who was the first to demonstrate that an applied current could orient the direction of neurite outgrowth along the lines of the electric field. His report also suggested that there was a different growth response toward the cathode (-) than toward the anode (+) of the applied field. However, in 1934, Paul Weiss, a scientist at Rockefeller University, published his experimental results claiming unequivocally that electric fields had *no* effect upon the orientation and growth of nerve fibers. The description of the experiments in Weiss's report was sketchy, and suggested serious flaws in the results. Yet, Weiss's work established what became the dominant belief on the matter.

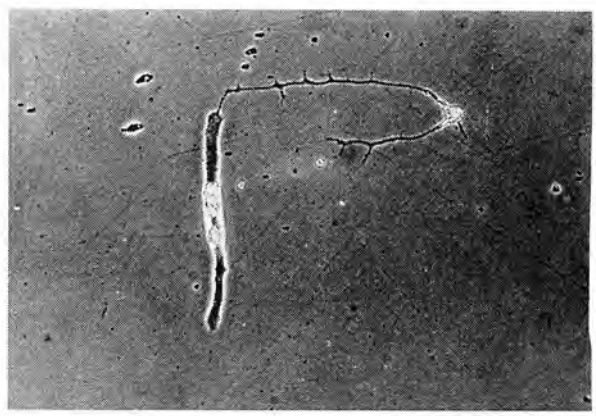


Figure 2
RESPONSE OF INDIVIDUAL NEURON, ISOLATED FROM THE NEURAL TUBE, TO ELECTRIC FIELD
The neuron (top right) extends neurites toward the negative (cathode) pole of the field (left). The long neurite is just touching the myoblast cell.

Source: K.R. Robinson, Purdue University

Robinson's mentor, Lionel Jaffe, had published a study of the response of dorsal root ganglion cells to an applied electric field in 1979, showing a preferential growth of neurites toward the cathode. However, the effect upon individual cells could not easily be seen, as these cultures contained hundreds or thousands of nerve fibers. Robinson was sure that Weiss's report was wrong, but he also wanted to be able to quantify the electric field strength required to influence the growth of an individual neuron.

Robinson's solution was to isolate the developing neurons from the neural tube of *Xenopus laevis* embryos, and grow them in culture in the presence of an electric field. In this way, individual cells could be studied, and the electric field threshold for an effect on neurite growth could be defined. In experiments in 1981, working with postdoctoral fellow Colin McCaig, Robinson found that the *Xenopus* neurons grew more neurites toward the cathode pole, and that neurites would make several turns orienting toward this pole. They found that the threshold for this effect was very low, a field strength of 7 millivolts per millimeter (mV/mm) could influence the cells.

They also tested the response of isolated myoblasts (muscle precursors) to the applied electric field in culture. The myoblasts had a higher threshold for response, of 36 mV/mm, and grew with their long axis of growth perpendicular to the poles of the electric field. These experiments established that different cell types responded in distinctive ways to an electric field, which would be important within an embryo whose cells are differentiating into specific cell types.

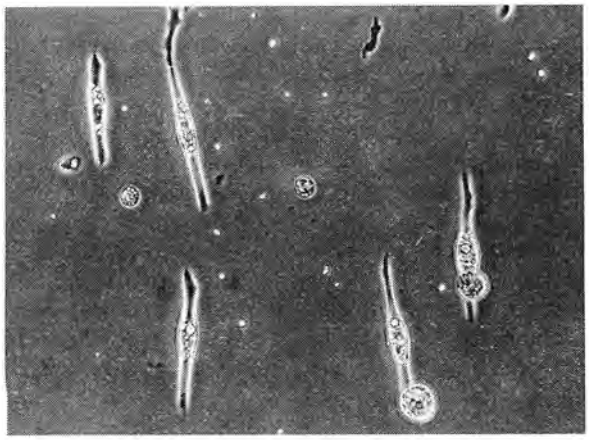


Figure 3
MYOBLASTS GROWN IN PRESENCE OF ELECTRIC FIELD

Myoblasts respond to the electric field by orienting their long axes perpendicular to the poles of the field (left negative, right positive). These cells are the precursors of muscle.

Source: K.R. Robinson, Purdue University

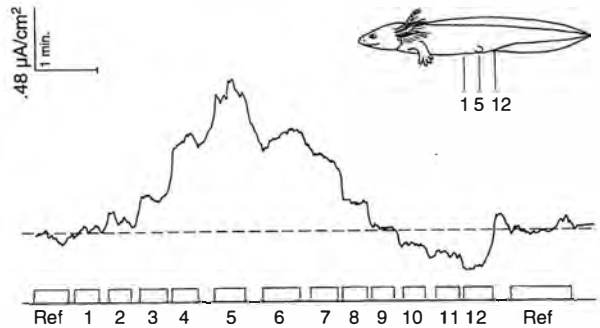


Figure 4
ELECTRIC CURRENTS MEASURED ALONG FLANK OF AXOLOTL DURING LIMB BUD FORMATION

Peaks above the dotted line indicate outcurrents, and below the dotted line indicate incurrents. The numbers represent the location on the axolotl where the measurements were taken. Note the strong outward current at position 5, which is the site of the emerging limb bud on the axolotl.

Source: R. Borgens, *J. Exp. Zool.*, Vol. 228, pp. 491-503, 1983. Reprinted by permission of Wiley-Liss, Inc.

Now that the fields required to influence the behavior of cells *in vitro* had been defined, the next step was to see if the embryo possessed fields of similar strength. McCaig and Robinson chose to study the *Xenopus* embryo during the process of neurulation, when the neural tube and the layout of the nervous system is first established. In experiments in 1982, they measured the electric potential generated by the ectoderm (outer layer) of the embryo, and found that it increased to 60mV (internally positive) or higher as neurulation proceeded. This voltage was much higher than those that they had previously found to be sufficient to effect the behavior of cells in culture. However, in this initial experiment they were not able to measure the direction or pattern of current flowing in the embryo.

During neurulation, cells must migrate from the area surrounding the neural tube to many locations in the body of the embryo. Could the electric fields be the cause of this migration, and do these fields guide the direction of the cell movements? An important group of cells that form around the neural tube and migrate to various distant locations is the neural crest cells. These cells differentiate into a wide variety of tissues, including ganglions of the autonomic nervous system, glands, skin, and even bone. It is not well understood what makes these cells migrate, and how they are directed to their destination.

Robinson isolated neural crest cells from *Xenopus* embryos, and exposed them to an applied electric field in culture. Individual cells and groups of cells migrated toward the cathode of the field at strengths of 10mV/mm or greater. This corresponds to a voltage drop of less than 1mV across the diameter of each cell. Fields of this magnitude could easily exist within the embryo, making electrical current a vector which could guide neural crest cell migration.

In 1984, Robinson used the vibrating-tip microprobe to try to detect the pattern of the currents near the surface of the *Xenopus* embryo. He found that positive currents were directed inward over most of the embryo surface, but that there was a strong outcurrent at the blastopore, which is a small hole in the ectoderm left from an earlier invagination of cells. This crucial experiment demonstrated that there was a global pattern of currents running through the embryo.

Embryonic Limb Development

What happens to embryonic cells in the region of the developing limb is fairly well defined anatomically in amphibians. Robinson and Borgens were eager to discover what role electric fields played in the events of limb formation in the embryo. Along the flank of the amphibian embryo, where the limb will form, one of the first things that happens is that the epithelial cells loosen their tight intercellular junctions. This creates a slightly leaky epithelium, which continues to degrade through the programmed death of some of the epithelial cells in the area of the limb bud. Beneath the epithelium, large quantities of mesenchyme cells accumulate, and later they start to migrate and grow outward. The migration of many cell types is involved in the process, including neural crest cells, fibroblasts, and, later, the growth of neurites extending into the growing limb bud.

Robinson examined the *Xenopus* embryo as it begins to form its hind limbs, and found that the area of the limb bud was the site of a strong outflow of current. Currents ranging from 2 to 12 $\mu A/cm^2$ left the limb bud, and returned in a loop to the surrounding areas of the flank. Because hind limb development occurs first in *Xenopus* and other frogs when the embryos are still quite small, and the time required for the process is rather short, it was difficult to make measurements of the current throughout the process of limb development.

Borgens took advantage of the larger size of the larvae, and the longer time frame for the development of the hind limbs,

in the axolotl to study the currents in limb development. The axolotl is rather well differentiated by this point in development, as its hind limbs develop after its fore limbs (Figure 4). Using the vibrating-tip microprobe, Borgens found, that for the week prior to the visible formation of the limb bud, the epithelial flank of the axolotl was an area of diffuse outcurrent, which became focussed and increased in intensity at the site of the limb bud. In fact, peak outcurrents of 2 to 3 μA/cm^2 occur at the site of limb bud formation, just before the limb becomes visible. The measurements of the current outflow could predict the exact site of the limb bud 4 to 6 days before it actually formed! The current path leaves the limb bud region and returns in loops to the areas of the flank, a short distance from the bud.

Borgens continued measuring the currents at the limb bud, finding that as the limb bud grows out from the epithelial flank, the current intensity decreases slowly, and in some cases, the current later reverses polarity and flows into the tip of large limb buds, approximately 0.5 mm in length.

From the experiments of Robinson and Borgens, a new understanding of limb formation has emerged. A developmentally programmed loosening of the tight junctions between the cells of the epidermis allows current to begin to leak out of the area where the limb bud will form. This disruption of the trans-epidermal potential leads to greater changes in the anatomy of the flank epidermis, such as the dying and sloughing off of epidermal cells in the region. The voltage gradient created by this current would be negative in the area of the leak.

The accumulation of mesenchyme cells, and the migration of other cells to the limb bud may be driven by the electric field. The limb bud area would act like the cathode of an electric field, which has been shown to direct cell migrations. Neurites also grow preferentially in this direction, which would innervate the developing limb.

Global Embryonic Electric Fields

The process of pattern formation within a developing embyro has fascinated scientists for decades. Robinson wanted to discover if the changes in the pattern of current flow could be correlated with physical changes in the arrangement of cells and tissues in the embryo. He and his student Kevin Hotary examined the embryonic chicken in 1990, measuring external current flows and voltage potentials in 2.5- to 4-day old chicks. They measured the currents surrounding the posterior intestinal portal (PIP), an area where the developing gut, near the tail, creates a break in the epithelium as it remodels. (See Figure 5.)

Measurements using the vibrating-tip microprobe were done on chicks from developmental stages 14-22. At stage 14, only weak currents flowing into the PIP could be detected, but by stage 16, the current reversed direction and flowed out from the PIP. The strong current flow outward from the PIP ranged from 50 μA/cm2 to a peak of 110 μA/cm2 at stage 17, and corresponded to the formation of the break in the epithelium of the gut.

Robinson and Hotary also measured the trans-epidermal potential of the chick embryos from the same stages of development, by inserting glass microelectrodes through the skin of the embryo. The average voltage potential across the skin was 16 mV, but this varied with the location on the embryo, and the stage of development. By taking many measurements of the change in voltage from head to tail along the embryo, they found that there was an internal voltage gradient averaging 10mV/mm toward the tail, which was the most negative. In regions close to the tail, the gradient was found to be as steep as 21mV/mm.

Neural crest cells begin to migrate in the chick at the stage where the first currents flowing out from the PIP are detected. Also, since neural crest cells were previously shown to migrate toward the cathode *in vitro* at field strengths of 10mV/mm or more, the voltage gradients measured in the chick would be more than sufficient to guide their migration toward the tail end, which acts as a cathode. As a result of these experiments, Robinson proposed that the major role of electric fields may be to guide the migration of cells in the embryo. But what else could the fields control?

The formation of the neural tube from the folding of the ectoderm, and subsequent detachment from the overlying layer of new ectoderm, lays the basis for the development of the central nervous system. After the neural tube forms, its presence induces the differentiation and patterning of other structures and organ systems. Undifferentiated cells in the vicinity of the neural tube will develop into specific cell types according to their position relative to it. Hans Driesch proposed nearly 90 years ago, that the developmental fate of an individual cell is a function of its position within the embryo as a whole.

Considering the neural tube's importance in determining the fate of the cells in the embyro, Robinson asked if the neural tube itself generated an electric field. To answer this question, he and Hotary inserted microelectrodes into the neural tubes of *Xenopus* embyros. By recording the electric potential across the wall of the neural tube, they found that there was a voltage of −23 mV through the dorsal (back) side of the tube, with the interior lumen being negative. The polarity is the opposite of that found at the ectoderm of the embryo, which maintains an inwardly positive potential; but this is not surprising, because

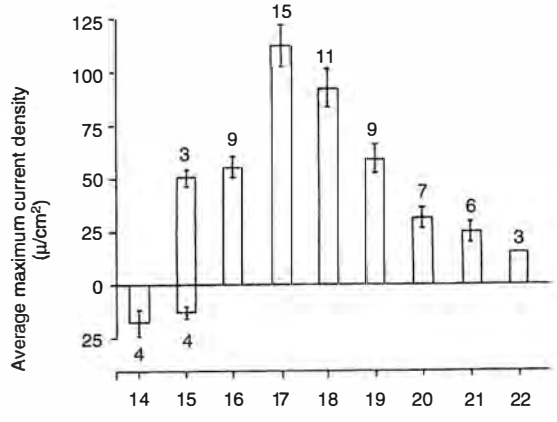


Figure 5
AVERAGE CURRENT DENSITY MEASURED AT POSTERIOR INTESTINAL PORTAL (PIP) OF STAGE 14-22 CHICK EMBRYOS
Currents peak at stage 17, and decline steadily thereafter.

Source: K.R. Robinson, *Dev. Biol.*, Vol. 140, pp. 149-160, 1990. Reprinted by permission of Academic Press.

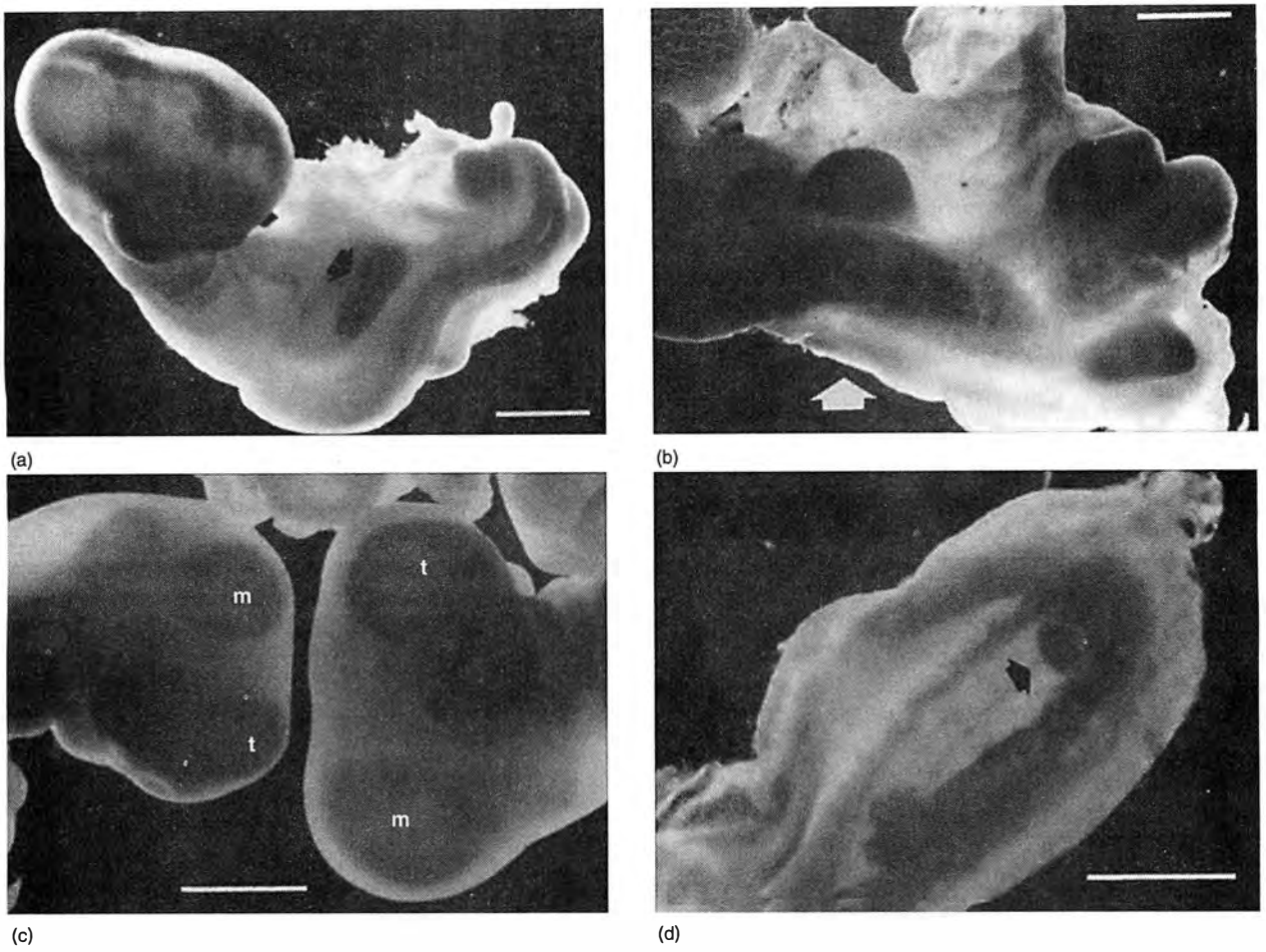


Figure 6
ABNORMALITIES IN LIMB, HEAD, AND GUT DEVELOPMENT IN CURRENT-SHUNTED CHICK EMBYROS
(a) Embryo has a duplicated wing bud on the side opposite the site of shunt implantation (arrow). The tail is also abnormal. (b) Wing bud is completely absent (arrow), while the leg buds are enlarged and flattened (asterisk). (c) Brain development is severely retarded in the current-shunted embryo on the left (asterisk). Brain divisions are small and abnormal, compared to the embryo on the right. The brain regions mesencephalon (m) and telencephalon (t) are labelled. (d) Ventral side of a current shunted embryo showing an abnormal outgrowth from the PIP (arrow).

Source: K.R. Robinson, *Development*, Vol. 114, pp. 985-996, 1992. Reprinted by permission of Company of Biologists, Ltd.

the neural tube interior is the same as the exterior of the embryo ectoderm, as a result of folding.

When the ventral side of the neural tube potential was measured, it was found to be more positive than the dorsal side. Surprisingly, areas just lateral to the ventral side of the tube differed in voltage by an average of 5mV. The pattern of electric potentials shows that the electric field generated around the neural tube is not radially uniform. Also, measurements of potentials around the neural tube in *Xenopus* embryos of various stages of development showed that the field intensity varied from stage to stage.

From the measurements, it was clear that the neural tube drives current primarily in a dorsal to ventral loop, creating strong fields that vary in magnitude from 50 to as much as 500 mV/mm. The cells near the lateral surfaces of the neural tube exterior would be exposed to very strong fields that would certainly influence their development. The somites that differentiate into muscle are found near the lateral walls of the neural tube, and *in vitro* experiments have already shown the response of myoblasts (which develop from the somites) to fields of only 36mV/mm. The neural tube electric field also coincides with the dorsal-ventral spatial patterning in the central nervous system.

Now that two major sources of electric fields have been discovered in the embryo, what is the importance of the interaction between the two fields during the embryo's differentiation?

Changing the Natural Current Topography

If the normal path of current flow were altered during the development of the embryo, what kind of effect would this have?

Robinson returned to the chick embryo, and devised experiments in 1992 which conclusively proved the importance of the electric field in development. Robinson and Hotary implanted tiny hollow glass shunts filled with an ionically conductive solution into the flank ectoderm of chick embryos between developmental stages 11-15. As a control, they implanted solid glass shunts that are not electrically conductive, in the same area in another group of embryos. The shunts were

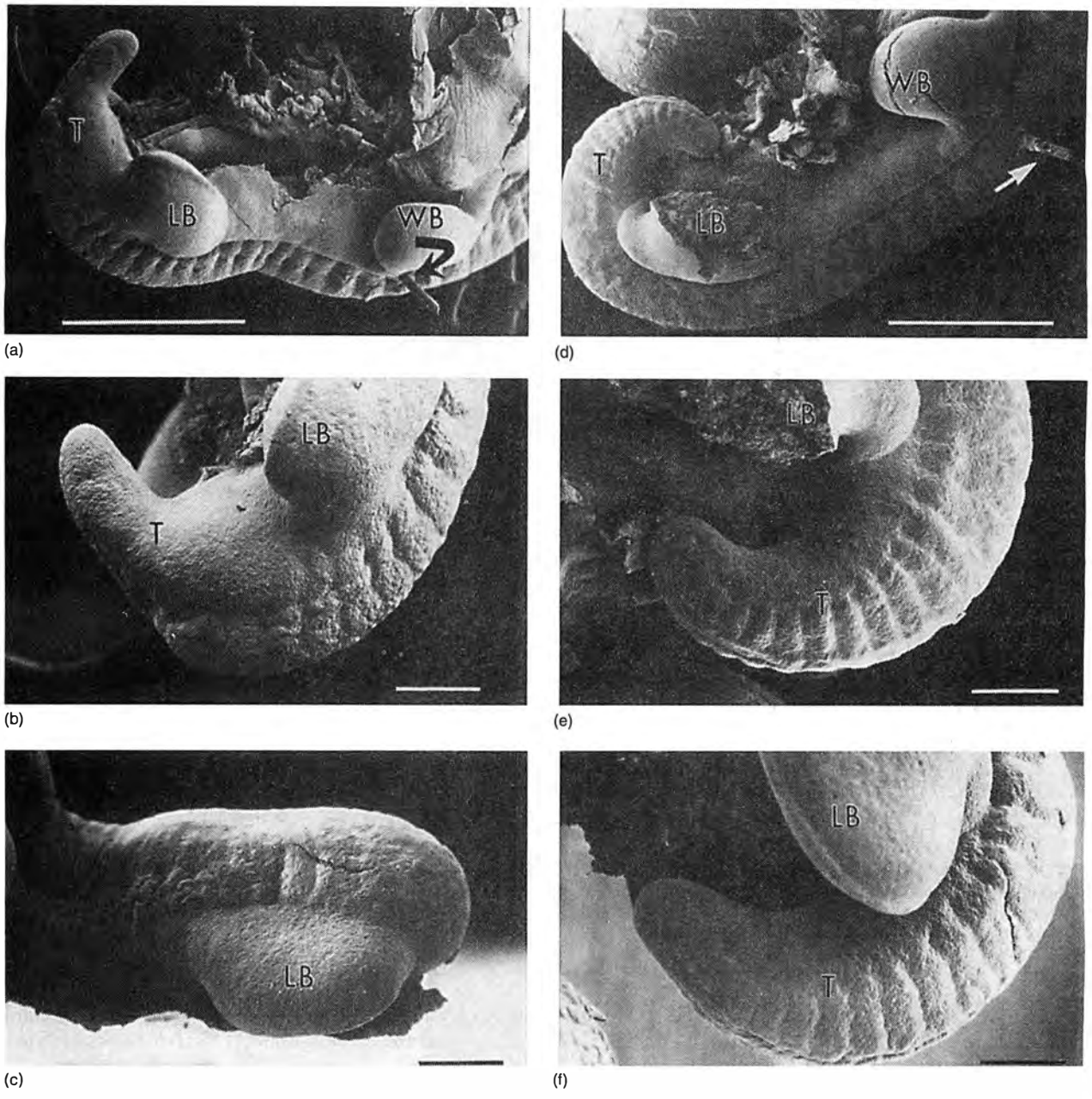


Figure 7
SCANNING ELECTRON MICROGRAPHS OF CURRENT-SHUNTED, SOLID-GLASS-IMPLANTED, AND CONTROL EMBRYO CHICKS

(a) Current-shunted embryo showing defective tail development. Arrow indicates the location of the implanted current shunt. (b) Closeup of the tail of embryo shown in (a). The end of the tail lacks a neural tube and other internal structures. (c) Current-treated embryo that failed to develop any tail. (d) Solid-glass non-conductive implant results in normal-looking structures in this embryo. (e) Closeup of tail region of embryo in (d), showing normal tail structure. Leg bud has been partially removed to allow better examination of the tail. (f) Normal chick embryo tail. Labels used are WB for wing bud, LB for leg bud, T for tail.

Source: K.R. Robinson, *Development*, Vol. 114, pp. 985-996, 1992. Reprinted by permission of Company of Biologists, Ltd.

implanted just before the appearance of strong outward currents from the PIP near the tail of the chick. Robinson expected his conductive shunts to reduce the natural current emanating from the PIP, and to direct the current out of the embryo in a different path.

After allowing the embryos to continue developing for a period up to three days, the embryos were collected and examined at stage 18 or 20. (See Figure 6.) The results in the current-shunted embryos displayed a staggering array of defects in structures throughout the body. About 92 percent of the current-shunted embryos showed some kind of defect, while only 11 percent of the solid-glass-shunt controls showed minor defects in development. Measurements of the current leaving the conductive shunts showed an average of 18 $\mu A/cm^2$ flowing out of the embryo, while no current could be detected flowing out of the solid glass shunts. Vibrating probe measurements of the PIP current in the conductive-shunt chicks showed a reduction of the current by an average of 30 percent, compared with a reduction of only 1 to 7 percent with the solid-glass shunts.

In the embryos whose current had been short-circuited by the conductive shunts, the most common defects were found in the tail region, which is consistent with the reduction of the PIP current. Tails were sometimes completely lacking in these embryos, and shortened tails were also found (Figure 7). In the few embryos that produced a tail of normal length, the internal tissue lacked normal structures, such as a complete neural tube, notochord, or somites. These embryos had abnormal gut structures, including sacs filled with undifferentiated mesenchyme cells.

The current-shunted embryos also displayed altered head development, including lack of brain divisions, and defective eye development, although at lesser frequencies. Defects in limb bud formation were also present, with missing limb buds or duplicated limb buds occurring on both sides of the embryo. None of the control embryos had altered limb buds.

Changing the path of the current flow had global effects on the embryo, and challenged the earlier notion that the electric field's primary influence on development was only through the guidance of cell migrations. Most of the events in embryo development do not depend on cell migration, and instead depend on the interpretation of position to direct differentiation.

Also, areas above the current shunts in the chick, such as the head, still showed a wide range of defects in development. Only a *field concept* of the control of development could explain these startling results. The disruption of the global electric field pattern in the embryo by the shunts may have altered cell recognition of position, which would help explain some of the results. The disruption also changes the interaction between the field produced by the ectoderm and the internal field produced by the developing spinal cord.

Embryonic Field Manipulation

In 1994, Robinson and Borgens each designed experiments to interrupt the endogenous electric field of early amphibian embryos through the use of an externally applied field. Before disrupting the field however, Borgens examined the embryos of *Xenopus* and the axolotl at the stage when the ectoderm is folding itself to form the neural tube. Using the vibrating-tip microprobe, he found strong ionic currents flowing out from the lip of the neural folds (Figure 8). Measuring laterally down the flank away from the lip of the folds, the outward currents decreased in intensity, and were found flowing inward at a distance from the folds. These outward current loops disappeared in this area once the neural tube was completely fused (Figure 9).

Trans-epithelial potentials were mapped in the larger axolotl embryos during the stages of neural tube formation. By insert-

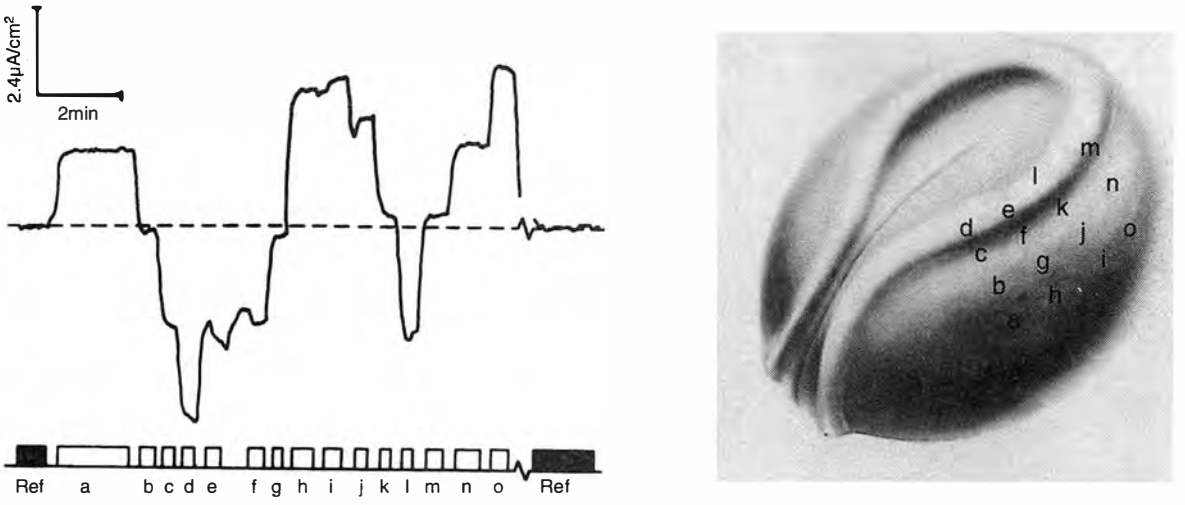


Figure 8
MEASUREMENT OF IONIC CURRENT AROUND NEURAL FOLDS OF *XENOPUS* EMBRYO
Graph (left) shows current flowing out of the embryo (below dotted line) and flowing into embyro (above dotted line). Letters below the graph correspond to the position on the drawing of the embryo (right). Outward currents are strongest near the lip of the neural folds; currents down the flank flow inward.

Source: R. Borgens, *J. Exp. Zool.*, Vol. 268, pp. 307-322, 1994. Reprinted by permission of Wiley-Liss, Inc.

ing glass microelectrodes into the area beneath the developing neural tube, measurements were made of potentials ranging from 18 to 64 mV. A voltage gradient from head to tail was found, with the tail being negative. The voltage differences between any two measurement points varied considerably, from 5 mV/mm to as high as 63 mV/mm. Again, the voltage gradient changed as the embryo developed.

Borgens then tested the effect of an applied field on the development of axolotl embryos. Embryos undergoing neurulation were oriented within a chamber, where they could be exposed to electric field strengths predicted to be similar or slightly higher than the natural fields. The embryos were oriented relative to the poles of the field in three ways: head towards the cathode, tail towards the cathode, or perpendicular to the cathode.

Severe abnormalities in body structures occurred in all three groups. However, the end of the embryo nearest the cathode displayed the most frequent and severe malformations (Figure 10). When the tail end faced the cathode of the field, tail and abdomen defects were the most common, and in many cases the head structures appeared normal in these embryos. In the opposite orientation, head defects predominated, with the tail structure appearing normal. The embryos placed perpendicular to the cathode showed an even distribution of defects to the head and tail regions.

Borgens also measured the trans-epithelial potential (TEP) of the embryos while they were exposed to the external field. With the tail facing the cathode, the TEP of the tail ectoderm underwent hyperpolarization, and increased in a range of 16 to 56 mV. The head ectoderm was depolarized, and often reversed polarity, with a change of 30 to 80 mV negative. The threshold field strength required to alter the TEP was found to be between 6 mV/mm and 25 mV/mm.

Robinson and his student Hotary took a different approach to altering the electric field in the *Xenopus* embryo. First, they re-examined the current flowing out of the blastopore, and found it to be much larger than their earlier measurements.

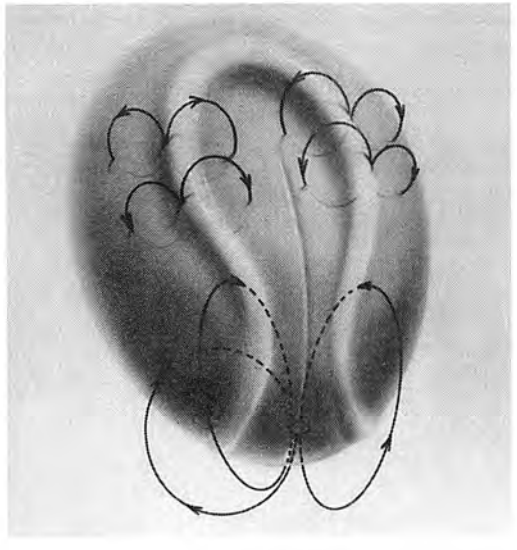


Figure 9
ARTIST'S DRAWING OF CURRENT LOOPS AROUND NEURAL FOLDS IN *XENOPUS* EMBRYO

The drawing is based on measurements done by R. Borgens. The loops at the bottom of the embryo depict the current leaving the blastopore. These currents drive the process of neural tube formation.

Source: R. Borgens, *Dev. Dynamics*, Vol. 202, pp. 101-114, 1995. Reprinted by permission of Wiley-Liss, Inc.

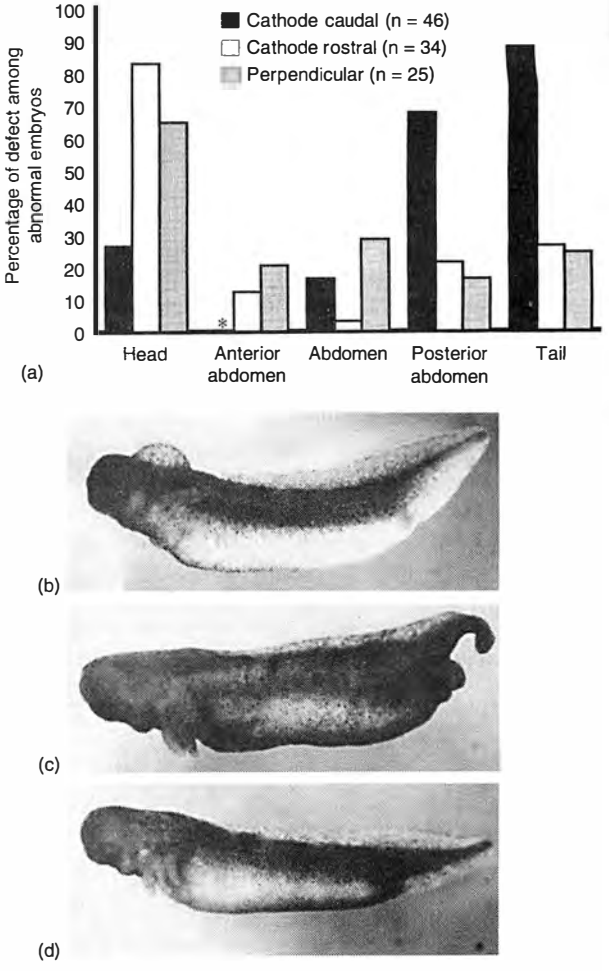


Figure 10
EFFECT OF 50MV/MM ELECTRIC FIELD ON AXOLOTL EMBRYOS ORIENTED IN THREE POSITIONS RELATIVE TO CATHODE OF FIELD

(a) The graph shows the percentage of defects in body regions in the three different orientations: cathode caudal (facing tail), cathode rostral (facing head) and perpendicular. (b) Embryo oriented with its head toward the cathode shows a large bulge on the dorsal surface of the head, as well as defects in other cranial structures. (c) Embryo oriented with its tail toward the cathode shows abnormal tail development, and bloated abdomen. (d) Unexposed control embryo showing normal structures.

Source: R. Borgens, *J. Exp. Zool.*, Vol. 268, pp. 323-338, 1994. Reprinted by permission of Wiley-Liss, Inc.

Currents were first detected flowing out from the blastopore at stage 14, peaking at stage 22, which coincides with the embryo's process of neurulation. The endogenous currents range from 2 to a peak of 115 μA/cm^2 over this period (Figure 11).

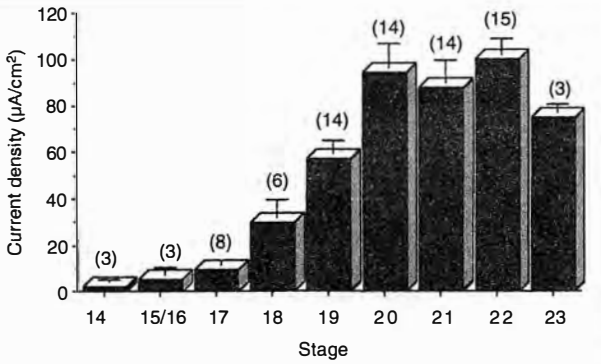


Figure 11
AVERAGE OUTWARD CURRENT DENSITIES MEASURED AT BLASTOPORE OF STAGE 14-23 *XENOPUS* EMBYROS

Numbers in parentheses above the bars indicate how many embryos were examined at that stage.

Source: K.R. Robinson, *Dev. Biol.*, Vol. 166, pp. 789-800, 1994. Reprinted by permission of Academic Press.

What if these natural currents could be nullified, or even reversed in polarity? What would be the effect on the development of the embyro? Robinson chose to use a microelectrode impaled just under the ectoderm of the embryo to disrupt the natural current flow. First, however, he had to determine what strength of current would be required to interfere with the blastopore current. By measuring the current flowing from the blastopore with the vibrating-tip microprobe, simultaneous with the application of current from the microelectrode, he found that an applied current of 100 nano-amps (nA) eliminated outward flow of current. Applied current of 500 nA effectively reversed the polarity of current flow at the blastopore, resulting in strong inward currents.

Xenopus embryos were impaled between stages 14 and 16, and the current was applied for up to 11 hours. One group of embyros exposed to 100 nA of inward current, nullifying the blastopore current, showed significantly abnormal structures in 20 out of 23 embryos. Common defects were found in head structure, absent eye development, and the failure of the neural tube to fuse at the anterior end. In many cases bulges appeared on the ventral surface of the embryo, which sometimes ruptured, spilling cells into the surrounding water (Figure 12). At higher levels of applied current, 250 nA or 500 nA, the abnormalities became more severe—Figure 12(f).

An additional experiment took two groups of embryos, and applied 100 nA of current in opposite polarities. In five embryos with inward current, all developed abnormalities. In the five in which an outward flowing current was applied, aug-

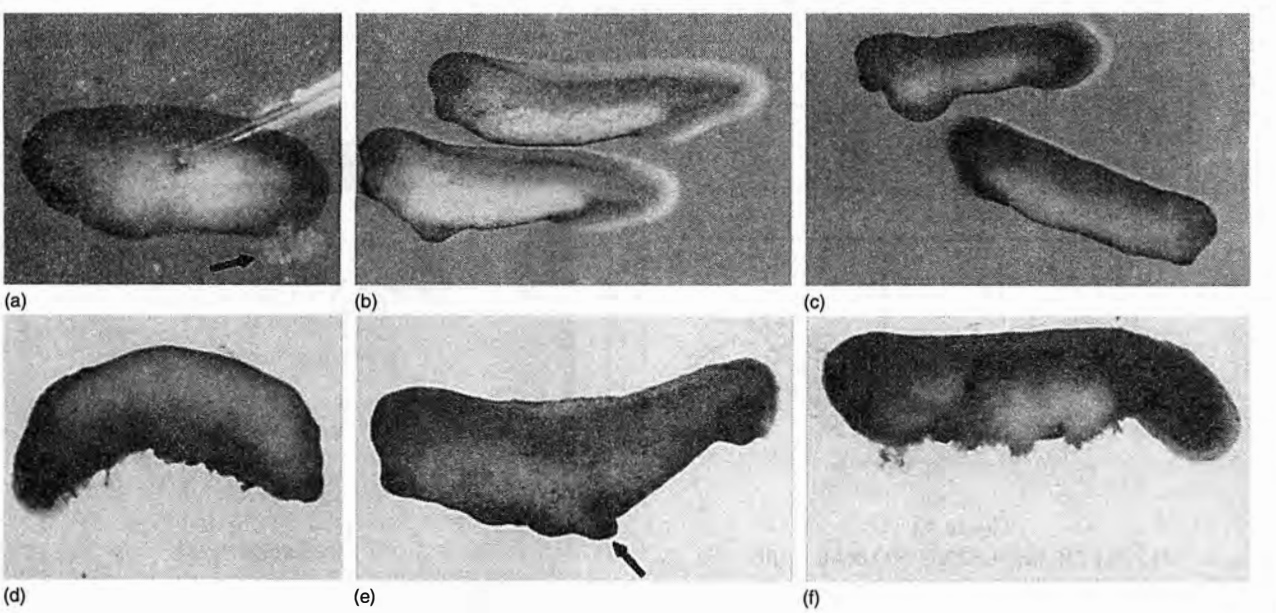


Figure 12
INTERNALLY APPLIED ELECTRIC CURRENT EFFECTS IN *XENOPUS* EMBRYOS

(a) A 100-nA inward current applied through the electrode nulls the natural current and causes cells to be ejected out of the blastopore. (b) Treated embryo shown at a later stage (at bottom), with an untreated control (above). Note the ventral bulge and bloated shape, as compared to the control. (c) Embryo treated with 100 nA (above) and control (below). (d) Embryo treated with 250 nA of current results in reduced head structures. (e) Embryo treated with 250 nA current, showing reduced head structure, abnormal tail, and an ectopic cement gland (arrow). (f) Embryo treated with 500 nA, which completely reverses the polarity of the natural current. It is disintegrating along its ventral side.

Source: K.R. Robinson, *Dev. Biol.*, Vol. 166, pp. 789-800, 1994. Reprinted by permission of Academic Press.

menting the endogenous current, only one of the five developed abnormally. The results reinforced the view that the disruption of the polarity of the global electric field in the embryo has serious effects on its development.

Can External Form Exist without Internal Differentiation?

In 1995, Borgens and postdoctoral fellow Riyi Shi did a series of experiments that demonstrated the crucial role played by the electric field of the neural tube in directing the differentiation of the internal structure of the embryo. The results also challenged the long held notion that internal differentiation of cells produces the external form of the embryo.

Axolotl embryos complete the formation and fusion of the neural tube by about stage 20 in their development. Borgens had previously measured the electric potential across the walls of the neural tube in the axolotl, and found that it was usually 80 mV to 90 mV, which produces strong electric fields that are not radially uniform in the surrounding cells. The ectoderm and the neural tube are both generators of electric fields in the embryo. Borgens wanted to test what would happen to the embryo if only the internal field generated by the neural tube were disrupted.

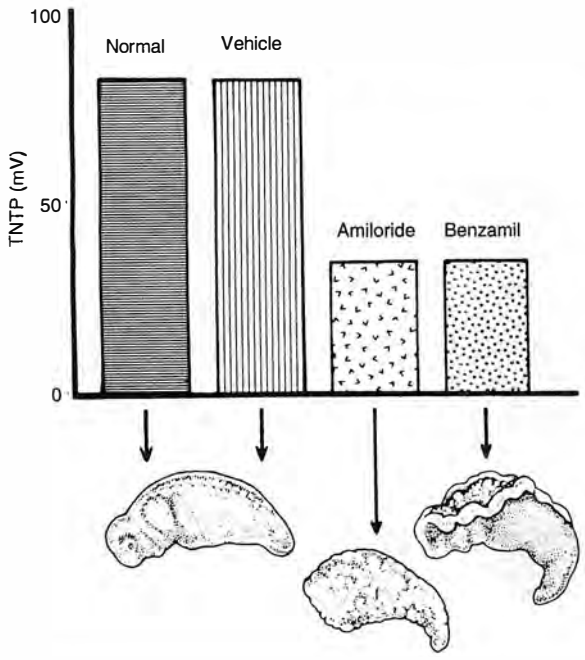


Figure 13
EFFECT OF REDUCING NEURAL TUBE ELECTRIC FIELD ON DEVELOPMENT

Bar graph shows the neural tube electric potential (TNTP) in embryos treated with the sodium channel blockers amiloride and benzamil, compared to normal embryo. Drawings below depict the severely abnormal morphology of treated embryos. The amiloride-treated embryo lacks all head structures. The benzamil-treated embryo's neural tube dissociates and exvaginates through the overlying ectoderm of the dorsal surface.

Source: R. Borgens, *Dev. Dynamics*, Vol. 203, pp. 456-467, 1995. Reprinted by permission of Wiley-Liss, Inc.

The electric potential of the neural tube depends largely on the transport of sodium ions and other positively charged ions out of the internal lumen of the tube. Borgens and Shi took advantage of this, by using the sodium channel blockers, benzamil and amiloride, to reduce the trans-neural tube potential

Figure 14
PSEUDOEMBRYO

A mid-sagittal section through a pseudoembryo, showing the complete lack of internal structure, with only undifferentiated clusters of cells. The normal internal structure of an axolotl embryo is superimposed (gray) just above the pseudoembryo. Note that the external shape of the pseudoembryo is basically normal.

Source: R. Borgens, *Dev. Dynamics*, Vol. 203, pp. 456-467, 1995. Reprinted by permission of Wiley-Liss, Inc.

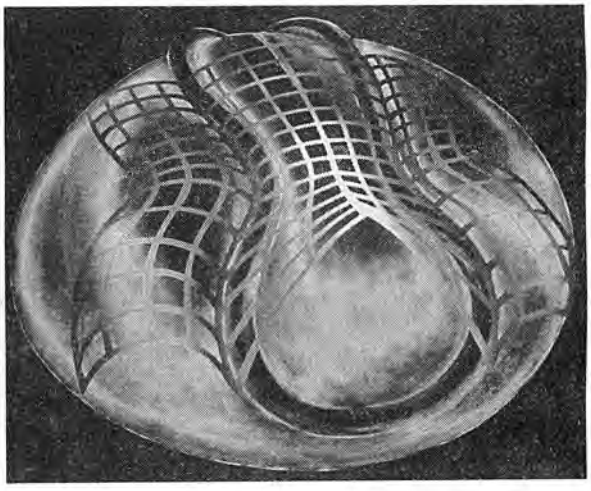


Figure 15
TOPOGRAPHY OF ELECTRIC FIELD ON SURFACE OF AMPHIBIAN EMBRYO

Artist's reconstruction of topography of electric field on the surface of an amphibian embryo. The graph depicts the intensity of voltage potential at the embryo's surface during neurulation.

Source: R. Borgens, *Dev. Dynamics*, Vol. 202, pp. 101-114, 1995. Reprinted by permission of Wiley-Liss, Inc.

(TNTP) in axolotl embryos at stage 21 to 23. When benzamil or amiloride was introduced into the lumen of the neural tube, the TNTP was found to be reduced by 50 percent or more (Figure 13). Treated embryos were then allowed to develop for 36 to 52 hours longer, when they were collected and compared to control embryos between stages 31 to 34.

In all of the embryos where the TNTP had collapsed as a result of treatment with benzamil or amiloride, there were severe abnormalities, of two different types. The first, was the formation of embryos which had completely chaotic internal organization, and grossly malformed external morphology. These lacked eye, ear, or neural tube structures, and did not resemble the control embryo's normal structure in any way. It was impossible to determine dorsal from ventral, or head from tail, because the major body axes were not present. Many of these embryos did not survive to stage 34.

The second group appeared as relatively normal in external form, with abnormal and undifferentiated internal structure (Figure 14). These were called "pseudoembryos." The pseudoembryos showed the disaggregation of the cells of the neural tube. They lacked all normal internal structures, including the gut. In embryos where groups of cells had started to form the primordia of the notochord and somites before treatment, these cells were found to be disassociated. Most of the body was filled with unorganized masses of undifferentiated cells. In some of these embryos, as the neural tube cells lost their polarity, these cells exvaginated in a sheet, and erupted through the overlying ectoderm, leading to the death of the embryo. It was determined that in the surviving pseudoembryos, the cells of the neural tube were not killed by the treatment with the sodium channel blockers; they just lost their ability to generate the electric field, which seems to determine their physical association.

The formation of these pseudoembryos challenges the concept that internal tissue differentiation determines the external form (morphology). In this case, disrupting the internal field of the neural tube led to a lack of differentiation of internal structure, yet the overall form of the embryo still developed in an almost normal fashion. Borgens describes this as the uncoupling of the global control of pattern formation from the local controls of tissue differentiation.

This may mean that the global external field produced by the ectoderm, which was not directly affected in the experiments, continues to guide the formation of the overall shape of the embryo, in the absence of the neural tube field. An analogous situation was also found in the formation of pseudolimbs in the electrically stimulated regeneration in adult frogs. The internal structure of the limb was abnormal and disorganized, yet the limb appeared almost normal externally.

These results cannot be explained by the traditional understanding of the relationship between internal tissue structure and external form.

A Field Theory of Development

There is an inherent paradox in the decades of research on electric fields in living systems. The cells are the source of the electric field, yet their behavior is subordinate to the field. Furthermore, the existence of the electric field may precede the movement or differentiation of the cells. This can be seen clearly in embryonic limb formation, where the current is flowing out of the area that will form the limb bud 4 to 6 days prior to its physical emergence. In many cases in embryonic development, the cells appear to "grow into" the shape and direction defined by the electric field.

This problem was studied by the great Russian biologist Alexander Gurwitsch, who in his 1922 paper "A Concept of Embryonal Fields," proposed that cells create a field that determines their future migration and growth patterns as an organism develops (Gurwitsch's work is discussed in the Spring, Summer, and Winter 1998 issues of *21st Century*.) Gurwitsch's concept was that the field was vectorial in nature, which is certainly true of the electric fields studied by Borgens and Robinson.

The work of Borgens and Robinson has produced a new field concept of development. Borgens proposed in 1995, that electric fields create three-dimensional voltage gradients that establish the coordinates of position, create the pattern, and influence the development of the embryo. From measurements of the field, it was possible to construct a topographical map of

Electric Fields Used to Treat Spinal Cord Injury

Dr. Richard Borgens is the head of the Center for Paralysis Research at Purdue University, where he has applied his interest in electric fields to treating spinal cord injury. After years of studying how electric fields can influence the growth of nerve cells, in 1992, Borgens investigated whether an applied electric field could help repair spinal cord injury in paralyzed dogs. He designed electric stimulators, whose electrodes could be implanted near the site of the spinal cord injury, to deliver an applied current of 200 micro-amps which creates a field strength of 135 to 210 micro-volts/mm.

In the mammalian spinal cord, axons extend from nerve cell bodies in both directions, so it was necessary to reverse the polarity of the field every 15 minutes, because axons grow preferentially toward the cathode of the field. In a clinical trial with injured dogs, the electric field stimulators produced a significant improvement in neurological function after six months. It was found that for the stimulators to be effective, the treatment must begin within two weeks after the injury.

Borgens and his colleague, Dr. Riyi Shi, have—for the first time—restored electrical impulse transmission in a severed, isolated mammalian spinal cord. Working with spinal cords isolated from guinea pigs, they used the polymer polyethylene glycol (PEG) to fuse the severed spinal cords. PEG fuses cell membranes, and when applied to the area of the break in the spinal cord, acts like cellular glue. When the PEG treated spinal cords were tested for electrical impulse transmission, it was found that 5 to 58 percent of impulses were restored. To be effective, the PEG treatment must be done within 24 to 36 hours.

This treatment is now being investigated in live animal models, and it is hoped it will eventually be used in clinical trials on humans. If successful, it could change the way spinal cord trauma is treated.

the electric field pattern on the surface of the embryo (see illustration on back cover). Currents flowing in the early embryo are aligned with the major body axes: head to tail, and dorsal to ventral. Voltage gradients, such as that found along the head to tail axis, offer a way for cells to know the coordinates of their position, and influence the direction and destination of migrating cells. The resulting fields within an embryo, such as the neural tube field, are not uniform in all directions.

Also, different areas of the embryo may have different resistance to current flows, creating a very complex and variable field pattern, which would be needed to create distinct tissues and structures. Cell types have different responses to an electric field, and different thresholds for an effect. Muscle cells orient themselves perpendicular to the poles of an electric field, while nerve cells grow their extensions preferentially toward the negative pole. The electric field allows the embryo to create singularities within itself, even though the field is global.

Robinson describes the embryo as creating electric current leaks and flows in a stage-specific and developmentally regulated manner. The embryo uses the flow of current and the electric field to drive the formation of the major structures and establish polarity of form. This is seen in the current flows associated with the folding of the neural tube, the early formation of the gut, and in limb bud development.

The pattern of the current flows and voltage gradients changes from stage to stage in development, and varies from species to species. However, *the pattern at any stage for a given species is invariant*. This concept directly echoes that of Gurwitsch's invariant principle. Gurwitsch also proposed that the embryonic field varied throughout development, but that this pattern was invariant for a given species. It is interesting to note the similarities in the ideas of Borgens and Robinson to those of Gurwitsch's field concept, although they were not familiar with the work of Gurwitsch.

Borgens and Robinson are currently working to bridge the gap between the vast amount of information about what happens at the molecular level, and their discoveries of the crucial role of the electric field in the development of the embryo. Scientists trained only in reductionist molecular biology would never be able to discover the *global* role the electric field plays in development. It is not possible to study all of the minute details of events that occur at the molecular level, and from that, determine that something larger must be controlling these varied processes. In fact, Borgens and Robinson were able to make these discoveries because they were trained in an historical perspective of science by mentors who were not trapped in reductionist ideology.

Commenting on the limitations imposed on today's scientists by the prevailing reductionist molecular ideology, Richard Borgens said, "It's taking the biology out of the biologist." The problem is that the reductionist approach has tried to reduce living processes to nothing more than molecular ping-pong, while avoiding the fundamental questions about the unique character of living systems. Kenneth Robinson amusingly said that he "would have dozens more grants if he could find one gene, or one ion channel" that was responsible for all of the electric fields he has found in decades of research!

The discoveries of Borgens and Robinson have laid the basis for a revolution in understanding how living organisms create electric fields to direct their growth and development. The next breakthroughs in biology will likely be made by those scientists who apply the field concept to solve problems at the molecular, cellular, and organismal levels.

Colin Lowry, a cell biologist, is an associate editor of 21st Century *magazine.*

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Eratosthenes' Instruments Guided Maui's 3rd Century B.C. Voyage

by Marjorie Mazel Hecht

What kind of astronomical knowledge and instruments did the ancient Egyptian mariners have to guide them on long-distance ocean journeys? The stunning decipherment of cave drawings and inscriptions by marine biologist and linguist Barry Fell in the 1970s, indicates that these ancient mariners had a sophisticated knowledge of the heavens, and a variety of astronomical instruments to calculate their position at sea and guide their way.

Fell's interpretation of the star maps and the astronomical instruments discussed here are convincing evidence both of the existence of ancient voyages across the Pacific, and of the capabilities of these mariners to know where they were going.

From Fell's decipherments, we know that a flotilla of Egyptian ships set sail in the 3rd century B.C., during the reign of Ptolemy III, on a voyage to circumnavigate the globe, and that they were guided by the knowledge of the astronomer Eratosthenes (c. 275-194 B.C.), which included astronomical instruments. Eratosthenes, the most important scientist of his time, headed the great library at Alexandria, and his friend, Maui, was the astronomer and navigator for the journey.

Maui left records of the journey of the fleet from Egypt in caves along the way, including drawings of his instruments, star charts, and the astronomical events of the time.

These inscriptions were brought to the attention of Fell in the 1970s, 22 centuries later, when he was working on deciphering the ancient Polynesian or Maori language. Fell's breakthrough was to decipher these inscriptions and cave drawings as a dialect of ancient Ptolemaic Egyptian, from which he translated them into English. His work on ancient Maori has not been publicized, and is found solely in *The Epigraphic Society Occasional Publications,* a society and journal that he founded in the early 1970s.[2]

A previous issue of *21st Century* recounted how Fell came to decipher the cave inscriptions from Irian Jaya, various Polynesian islands, and Chile.[1] Here, we look at some of Fell's work on Maui's astronomy, and a description by Fell's colleague, Sentiel Rommel, of the reconstruction of one of Maui's astronomical instruments (p. 75).

From Fell's translations, we know that the Egyptian flotilla of six ships, with Rata as captain and Maui as navigator, landed in Sosorra, McCluer Bay, Irian Jaya (the western part of New Guinea), around 232 B.C., leaving many drawings and inscriptions in what are called the Caves of the Navigators. The cave inscriptions were discovered

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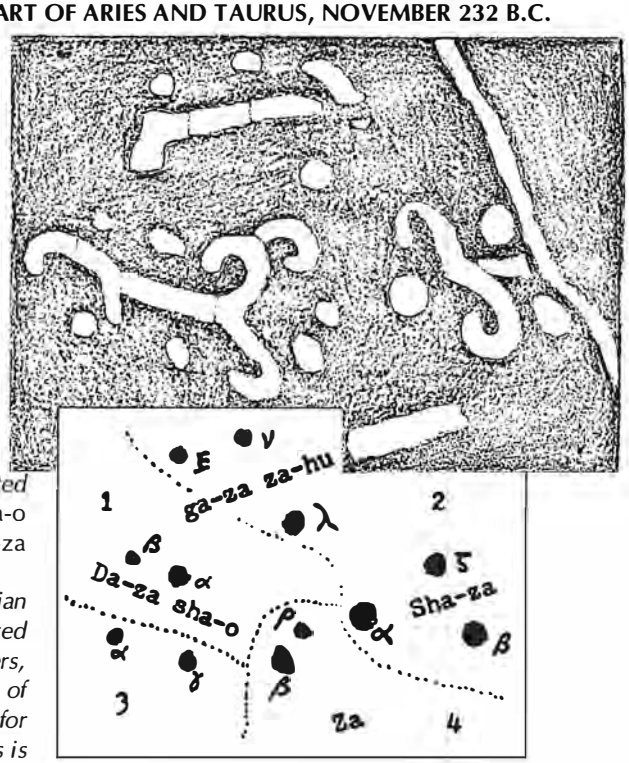
Figure 1
MAUI'S STAR CHART OF ARIES AND TAURUS, NOVEMBER 232 B.C.



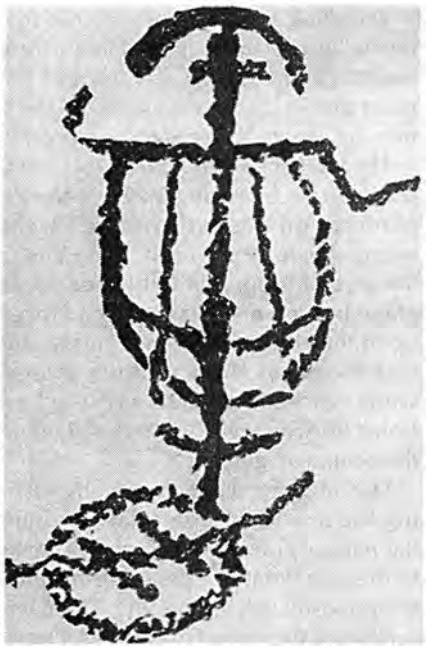
Inset (bottom) in Maui's drawing from the cave on Wamera Island is Fell's interpretation of the star chart. The four constellations shown are (1) Aries, (2) Taurus, (3) Triangulum, and (4) Perseus. The Egyptian hieroglyphs are left, Ba *(Ram); right* Shasaw *(Head of the Buffalo).*

Fell translates the script as follows: Za ga-za za-hu *(The Zodiac Tilted Upside-Down);* Da-za Sha-o *(First Node); and* Sha-za *(Head of the Buffalo).*

Fell notes that the Egyptian hieroglyphs are constructed out of ancient Maori letters, adding another dimension of meaning. The hieroglyph for Ram, for example, he says is composed of the Maori letters, reading from left to right, "The knot (node) of the starting point, that is, the node that marks the beginning of the ecliptic, or the first point of Aries in modern nomenclature." Similarly, the hieroglyph for buffalo, he says, "has been placed on its side, so as to form the Ancient Maori letters Sha-sa, *meaning 'Forepart of the Buffalo' or Head of Taurus."*

Maui's Tanawa: A Torquetum of 232 B.C.

by Sentiel Rommel, Ph.D.



From *America B.C.* © Barry Fell (New York: Simon & Schuster, 1976), p. 118

Drawing by Maui of his tanawa, found in the Caves of the Navigators, Irian Jaya.

EDITOR'S NOTE

Sentiel Rommel, a marine biologist with experience in navigation, worked with Barry Fell in the 1970s, and spent four months constructing a model of Maui's Tanawa. A graduate of the U.S. Naval Academy at Annapolis, Rommel has a master's degree in engineering and a Ph.D. in oceanography from the University of Maine. Rommel is now working on the anatomy and physiology of marine mammals at the Florida Department of Environmental Protection.

This article is adapted from his paper of the same title, published in The Epigraphic Society Occasional Publications, *Vol. 2, No. 29, Feb. 1975. It appears here by permission of the author and the Epigraphic Society.*

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The axis of the Earth's rotation is inclined 23.5° to the plane of the Earth's orbit of revolution about the Sun. The projection in the sky of this plane is called the ecliptic, and in the course of one year, the Sun, as seen from the Earth, completes one revolution along the ecliptic. Since the planets also move in orbits, whose places are nearly parallel to that of the Earth, they too are seen to move across the sky in paths that nearly match the ecliptic.

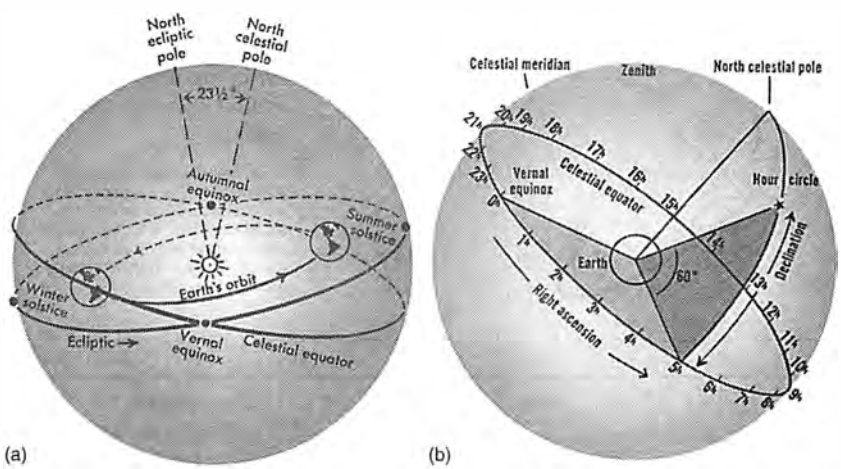
By the time of Eratosthenes, it had evidently become apparent that a more satisfactory treatment of planetary motions would emerge if their positions were measured in coordinates based upon the ecliptic, rather than those based upon the Earth's axis of rotation. Accordingly, an instrument was invented, perhaps by Eratosthenes—by which an observer might read off ecliptic coordinates directly, once the instrument was correctly oriented with respect to the Earth's axis.

Today we have sophisticated computers that can rapidly calculate the posi-

Figure 2
THE EQUATORIAL SYSTEM

The celestial sphere is the imaginary canopy, concentric to the sphere of the Earth, devised to provide a way of charting the course of the stars and locating an object in the sky from any point on Earth. The celestial poles are directly above the terrestrial North and South poles.

The Earth's equator is inclined by 23½° to the Earth's orbit around the Sun (a). The ecliptic, the path of the Sun, is thus inclined 23½° to the celestial equator. The ecliptic intersects the celestial equator at two points, called equinoxes. The Sun, moving north, arrives at one of these points on March 21—the vernal equinox. In the fall, the Sun crosses the celestial equator 180° south at the autumnal equinox. The summer and winter solstices occur at the two points, each 90° from the equinoxes, when the ecliptic is farthest from the celestial equator.



The starting point for locating stars in the equatorial system is at the vernal equinox (b). A great circle (called the hour circle) is imagined through a star, from the north celestial pole to the celestial equator. The angle from the vernal equinox, eastward to where the star's hour circle meets the celestial equator, is called the right ascension of the star, and is usually measured in hours, minutes, and seconds of time.

The altitude of the same star, its declination, is a measure of the angle it makes with the celestial pole, and is measured in degrees, from 0° at the celestial equator, to 90° at the north celestial pole (−90° at the south celestial pole). In the example shown in (b) the star has a right ascension of 5 hours and a declination of +60°.

Source: Adapted from *Modern Space Science* by Frederick E. Trinklein and Charles M. Huffer (New York: Holt, Rinehart and Winston, Inc., 1961)

tions of planets and stars in ecliptic coordinates, given an initial input of data in terrestrial coordinates of declination and right ascension [north-south and east-west]. A device that can perform these calculations mechanically—an analog computer—is called a torquetum. The oldest existing European torquetum dates from 1444 A.D.

Study of a painting found in a cavern at Sosorra in Irian Jaya (West New Guinea) and of an accompanying rebus deciphered by Barry Fell, disclosed a device that would function as a torquetum (Figure 1). It is named in the inscription as "the tanawa (or calculator) of Maui." I have constructed a torquetum, or tanawa, by using this cave painting as a guide.

Reconstructing Maui's Tanawa

A torquetum must have a plane parallel to the Earth's equator for two purposes: (1) to provide a reading of right ascension, that is, celestial longitude as measured from the First Point of Aries; and (2) to provide a support and pivot about which another plane, in disk form, may rotate in the equatorial plane. This equatorial plane is made by tilting a platform from the vertical by an angle equal to the latitude of the observer (Figure 2).

The device must be oriented so that the inclined plane is normal to the local meridian, the horizontal through the pivot then lying east-west; the plane is then parallel to the equatorial plane.

The tilt of the Earth's axis is then compensated for by setting a wedge-shaped platform on the equatorial disk, the wedge-angle being 23.5°. One side of the wedge is applied to the equatorial plane in such manner that it can rotate upon the equatorial plane. This means that the other surface of the wedge, when correctly aligned with the First Point of Aries, will lie in the plane of the ecliptic (Figure 3).

This alignment is achieved by rotating the movable equatorial disk until the intersection of the two planes points to the First Point of Aries (or its nadir on the opposite side of the sky). The intersection of the two planes of the torquetum is now parallel with the intersection of the plane of the Earth's equator with the plane of the ecliptic.

Next, an upright column is placed on the apparatus, perpendicular to the plane of the ecliptic, and consequently, parallel to the ecliptic axis and pointing, therefore, to the poles of the ecliptic. A transverse sighting arm, movable in planes vertical to the ecliptic plane, is attached to the polar axis. When provided with a suitable angular scale, this arm will now read the ecliptic latitude of any celestial object to which the sighting arm is directed.

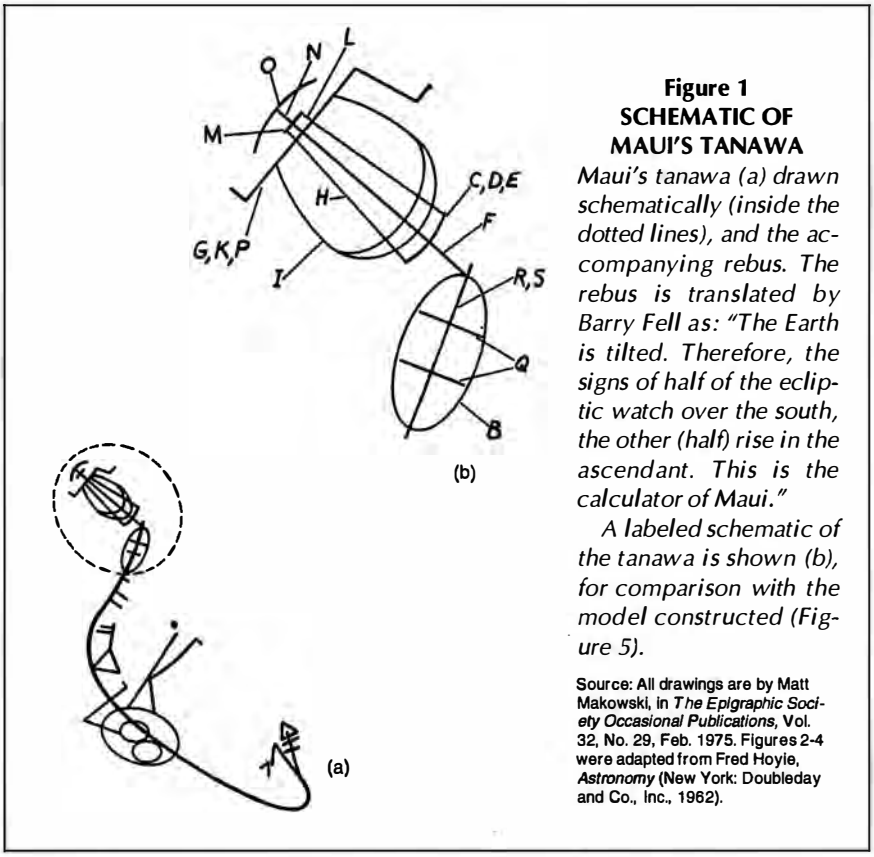


Figure 1
SCHEMATIC OF MAUI'S TANAWA

Maui's tanawa (a) drawn schematically (inside the dotted lines), and the accompanying rebus. The rebus is translated by Barry Fell as: "The Earth is tilted. Therefore, the signs of half of the ecliptic watch over the south, the other (half) rise in the ascendant. This is the calculator of Maui."

A labeled schematic of the tanawa is shown (b), for comparison with the model constructed (Figure 5).

Source: All drawings are by Matt Makowski, in *The Epigraphic Society Occasional Publications*, Vol. 32, No. 29, Feb. 1975. Figures 2-4 were adapted from Fred Hoyle, *Astronomy* (New York: Doubleday and Co., Inc., 1962).

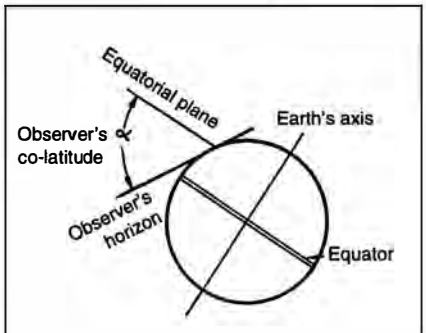


Figure 2
SCHEMATIC OF EQUATORIAL PLANE

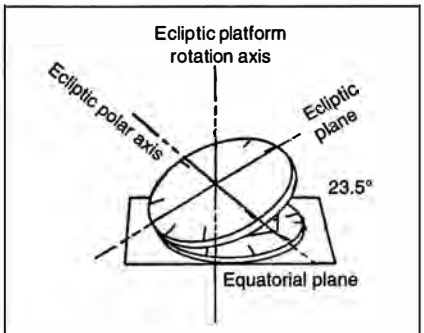


Figure 3
SCHEMATIC OF ECLIPTIC PLANE AND AXIS

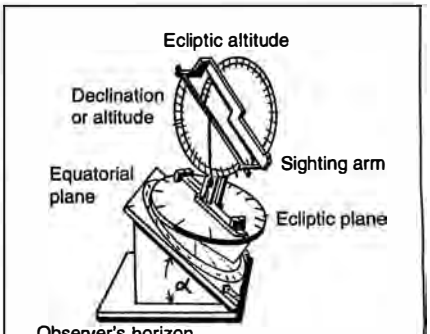


Figure 4
SCHEMATIC TORQUETUM

At the same time, by rotating the calibrated ecliptic plane, in the process of bringing the sighting arm to bear upon the object under observation, the amount of rotation required in that plane is a measure of ecliptic longitude. If, in addition, a plumb-bob and free-hanging calibrated plumb-arc be attached to the sighting arm, so that both members hang always in the vertical plane, a reading of the intercept of the plumb-bob with the plumb-arc yields local elevation (or, alternatively, zenith angle) of the celestial object being sighted.

At the instant when the celestial object crosses the meridian, the plumb-bob reading becomes a measure of declination (that is, a celestial "latitude" with respect to the celestial pole of the Earth's rotation). This means that if the known declinations of conspicuous stars are tabulated, the observer can derive his latitude in this way in the first place, and so determine the correct angle to set into the equatorial plane before beginning to make measurements in ecliptic coordinates. However, it is virtually certain that latitude would already have been determined by day, using the cross-staff and astrolabe.

There are two times during the day when the observer's meridian is in quadrature with the First Point of Aries. At one of these times, if the instrument is appropriately calibrated, it can be used as a time-piece. This, however, is much more easily accomplished with the astrolabe, and another cave drawing indicates that an instrument of the astrolabe type was known to Maui.

I constructed the tanawa or torquetum of Maui in brass, using the cave rebus as a "blueprint." Some modifications were made in building the first model (Figure 4). This more modern tanawa has an ecliptic platform set at 23.5° to the equatorial platform. In the model made in accordance with the rebus drawing (Figure 5), on the other hand, the latter feature was eliminated simply by constructing the ecliptic polar axis at 23.5° from the perpendicular to the equatorial plane. At first this is a little more difficult to visualize than the torquetum shown in Figure 4, but the simplicity lends itself to a very portable and easily constructed instrument.

Figure 5
BRASS MODEL OF MAUI'S TANAWA

A Base, in the plane of the observer's horizon, oriented so that the axis of symmetry is parallel to the meridian.

B Equatorial plane, set parallel to plane of Earth's equator by tilting it from the horizontal by an angle equal to the co-latitude. In the example modelled, it is adjusted for latitude 45°, whereas, in Maui's version, located in New Guinea at about 5° S latitude, the co-latitude becomes 85° and so the equatorial plane is nearly vertical (Figure 1). The upper platform can be swivelled to bring plane *C* into the ecliptic plane by sighting on the first Point of Aries.

C Ecliptic plane (viewed from one side in Maui's figure, hence appearing as a line), set parallel to the plane of the ecliptic, and calibrated to read ecliptic longitude: shown proportionately slightly larger than in the cave figure, to give added stability.

D Reinforcing rod for *C* (viewed in Maui's figure from side, to appear, therefore, as a line, part of *C*).

E Indicator for reading ecliptic longitude, and base for rotating the upper part around the ecliptic axis (viewed in Maui's figure from side, and hence not distinguished from *C*).

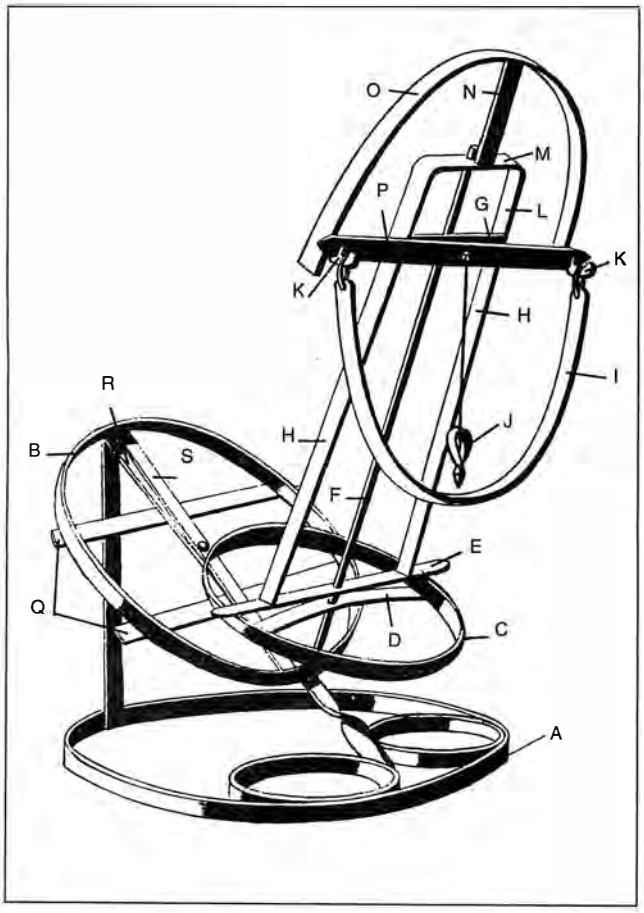
F Ecliptic axis of rotation (viewed from front in Maui's figure). Certain differences were introduced into this model in the belief that they would improve its stability, but is now realized that, in fact, good stability is given by following Maui's assembly exactly.

G Reinforcing rod to support *P* and *J*.

H Upright for bipod support and swivel for sighting arm. (In Maui's version, these structures are viewed from the front.)

I Swivel- or plumb-arc, for measuring altitude (and declination at meridional passage) of a planet or star. This segment swings away from the ecliptic axis as the ecliptic plane indicator is rotated to bring the object into alignment with the sighting arm. The action of this section performs a mechanical solution of the spherical trigonometry involved in converting from ecliptic coordinates to celestial.

J Plumb-bob, the indicator for *I*, upon which degrees (or some unknown units of arc) would be engraved.



K Viewing sights, also acting as pivots for *I*. The planet or star is viewed along these sights by performing the mechanical motions permitted by the moving axes of the instrument, thereby automatically setting in to the dials the data required on the ecliptic coordinates.

L Extension of *H* (assumed). The exact nature of this part was not clear in the available reproductions of the cave drawing, but it seemed necessary to construct the model in this way. It is shown as a dotted line in the enlarged version of Maui's sketch in Figure 1 (b).

M Cross bar and swivel of *F*, the ecliptic axis.

N Extension of *F*, viewed in cave figure as not being different from *F*, but required as support for *O*.

O Arc of ecliptic latitude, slightly extended beyond the limits shown in the cave figure, to permit measurements over a wider arc. Note: Fell believes this portion of the original drawing can be interpreted differently, so as to allow a 360° range of ecliptic latitude.

P Sighting arm for *K*, with supports for *I*.

Q Supports for equatorial plane, as shown by Maui.

Crucifying Science and Religion

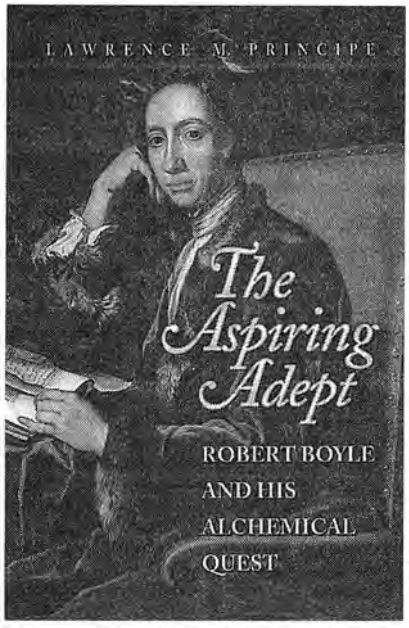
by David M. Shavin

The Aspiring Adept:
Robert Boyle and His Alchemical Quest
Lawrence Principe
Princeton, N.J.: Princeton University Press, 1998
Hardcover, 339 pages, $45.00

If John Maynard Keynes was the Mad Hatter, inviting the world to come through the Looking Glass and view the tortured mental life of Sir Isaac Newton, then perhaps author Lawrence Principe, with his *The Aspiring Adept: Robert Boyle and His Alchemical Quest,* is content to make us feel welcome at the Tea Party. To quote Principe, "That Newton, or Boyle, or Locke, or any other seventeenth-century natural philosopher should have believed, dabbled, labored, or sweated in alchemy should no longer horrify the sensibilities."

In the 1940s, Keynes addressed an inner elite at Cambridge University, introducing them to the mysteries locked away in a chest of Newton's papers: "Newton was not the first of the age of Reason. He was the last of the magicians, the last of the Babylonians and Sumerians. . . ." However, once Earth Day had launched the "post-industrial" age in 1970, it became more acceptable to make public Newton's kinkier side. In Principe's own evaluation, Betty Jo Teeter Dobbs's 1975 book, *The Foundations of Newton's Alchemy,* "ushered in a completely new view of the man. . . ."

Now, Principe brings his sensitivity to the many different ways of being an alchemist, to the story of Newton's predecessor, Robert Boyle (1627-1691). Instead of casting doubt upon the bogus nature of the vaunted "rationality" sold under the patent name of "Boyle," Principe would "restore the traditional alchemical dimension to Boyle's work and thought." In other words, Boyle and Newton might have sweated over their closet irrationality, but today we can take a more "healthy" view, and reject the outmoded separation of rational and irrational.



Again, to quote Principe: "Boyle was not as 'modern' as we thought, nor alchemy as 'ancient.' What we are witnessing, then, is a rapprochement between what have previously been seen as two separate and irreconcilable halves of the history of chemistry."

The reader may await some purportedly rational explanations or suggestions as to what actually are the claimed transmutations that Newton and Boyle carry out. Or perhaps the reader might search in Boyle for some primitive but honest research into the interconnectedness of the chemical elements. Historically, there have been investigations into causal connections of the elements that have fallen under the classification of alchemy. However, what is offered here is not science, but a dissertation on the validity of "witnessing." Here, "truth" is not particularly reproducible nor coherent, nor social; instead, it is what is asserted by important people.

Boyle's Obsession

As long as the reader remembers on which side of the Looking Glass he or she is on, however, there are several jewels to be gleaned from Principe's extensive work. He has ventured through the writings of Boyle in the library of the British Royal Society, and has reconstructed, for the first time in full, Boyle's lost *Dialogue on the Transmutation and Melioration of Metals.* Principe's appendix also offers a reconstruction of a partial work, *Dialogue on the Converse with Angels Aided by the Philosophers' Stone.* Although these works do exhibit, as Principe claims, "the undeniable magnitude of the traditional alchemical component of Boyle's work," it is unlikely that they come close to approaching the volume of Newton's writings—whose manuscripts were almost completely devoted to alchemy, to prophecy, and to studies attacking the Trinity.

A Lifelong Obsession

In Boyle's case, Principe estimates some sort of rough equality: "In terms of the number of years this material attracted his attention and the number of experiments and people it involved, the quest for the correct preparation and deployment of the Philosophical Mercury rivals in importance Boyle's vastly better known studies of the air." However, Boyle is shown, like Newton, to have had a lifelong obsession with alchemy—from his early collaboration with George Starkey, also known as Eirenaeus Philalethes, to the handing over of his mysterious "red earth" to John Locke (and Newton) upon his death.

Newton kept himself removed from Boyle's projects, objecting to the quasi-public nature of his older colleague's venture. In 1676, Newton wrote to the Royal Society's Oldenburg, that Boyle should "preserve high silence" regarding such sensitive matters. The reclusive Newton was probably leery of the public project, launched by Oldenburg and Boyle, to establish contact with powerful Adepts, and learn the secrets of the transmutation of metals.

Boyle believed that "there lives conceal'd in the world, a sett of Spagyrists of

a much higher order . . . being able to transmute baser Metalls into perfect ones, and do some other things, that . . . divers of the more judicious even among the Spagyrists themselves have judg'd impossible." Boyle's "On the Incalescence of Quicksilver with Gold" (1676) advertised Boyle as the contact person with whom Adepts could get in touch. In it, he maintains that his special mercury has succeeded in breaking down gold, but he needs to know how to reverse the procedure, that is, to obtain the Philosophers' Stone.

Boyle's paper is designed not to say too much. Principe quotes Boyle: ". . . [O]pen knowledge of the Stone would 'much disorder the affairs of Mankind, Favour Tyranny, and bring a general Confusion, turning the World topsy-turvy.'. . . Thus this Philosophical Transactions paper should not be read as . . . making knowledge public but rather as an attempt to contact adepti. . . ."

Newton wants to be in on the secret, but is afraid of the entanglements. His letter to Oldenburg stated that he is "desirous of the sense of others in this point. . . [and particularly the sense] of a true Hermetic Philosopher, whose judgement. . . would be more to be regarded in this point than that of all the world beside to the contrary. . . . [T]he fingers of many will itch. . ." to learn the secret formula.

Newton suspected that Boyle and Oldenburg were running an intelligence operation. Principe explains that, after Boyle's death, "Newton complains that Boyle offered his secrets only under strict conditions, and even after Newton agreed to these, Boyle still concealed crucial steps. Newton writes that in offering some other receipts, Boyle 'cumbered them with such circumstances as startled me and made me afraid of any more.'"

Secret Agents

Boyle and Oldenburg might have gotten more than they bargained for. In the most fascinating portion of Principe's book, a 20-page section titled "Georges Pierre and the Asterism," the Royal Society advertisement by Boyle and Oldenburg is shown to have garnered a response in June 1677. One "Georges, patriarch of Antioch," orders a Frenchman named "Georges Pierre" to show Boyle the alchemical "projection" to compose pure gold, telling him "it will not be long before God allows [Boyle] to enjoy the happiness of being a true philosopher."

The ensuing twists and turns of this affair remind this reviewer of the Venetian games adumbrated in Schiller's story *The Ghost-seer*. Principe himself refers to the year initiated by Pierre's visit, as Boyle's "annus mirabilis alchemicus of 1677-78."

Briefly, Pierre works for a "Georges du Mesnillet of Constantinople," leader of a society of alchemical masters, sometimes called "Asters," to which Boyle is invited to apply. The seduction involves a magical powder, exchanges of gifts, and attempts on both parts to extract what the other knows. Boyle is to provide some items, like luxurious fabrics costing about 50 pounds, for which du Mesnillet's banker, a Gaspard Cassati of St. Mark's Square, Venice, will reimburse about 115 pounds to Boyle.

Boyle is instructed to acquire many more gifts (pearls, satins, brocades, silk carpets, and so on), and to have himself "received into the India Company, and the quicker the better." Evidently, Boyle was already, as of April 1677, on a committee of the East India Company, and he was re-instructed to become also a "freeman of the Turkey Company," which he did in May 1678.

Of course, the patriarch then writes to regret that the "blessed powder that I entrusted to Mr. Pierre" was lost, as it was "sent to Mr. Des Mulens when he was in Italy with the son of My Lord Halifax; I do not doubt that he projected it somewhere or other."

Now, Lord Halifax was a neighbor of Boyle, and the tutor of his eldest son, Henry Saville, was indeed, one Du Moulin. And the two were together in Italy during that period. Why the nonexistent "Georges du Mesnillet of Constantinople" chose to impute the Halifax family as one of the confirmable references, is of some note. Regardless, the "blessed powder" was never produced.

Although Boyle does refer to an initial "teaser" amount of powder in his composed dialogue "Anti-Elixir" (1678), including specific reference to a "Foreign Virtuoso" with an "Eastern Patron" who gave Boyle "a minute quantity of powder," and although he might have gotten an initial demonstration with Pierre handling the powder, Boyle certainly never got the larger amount of "blessed powder" to work with himself.

Boyle submits his papers and secret formulae to the assembly of Asters to prove that he qualifies to be admitted. He gets suggestive but indefinite indications of secret knowledge in return. Once, Boyle gets a "transcript from the journal-book of the Cabalistic Society of Philosophers" nominating him for an important post. However, the story continues for years, with Boyle in an elusive chase for the secret formula, for the Aster adepts, and for the promised secret chest, which holds the "book of life," and more! His proxy, Mr. Pierre, is delayed, as vague references are made to prison threats, to an exploding cannon that accidentally killed four people, to lawsuits, and so on.

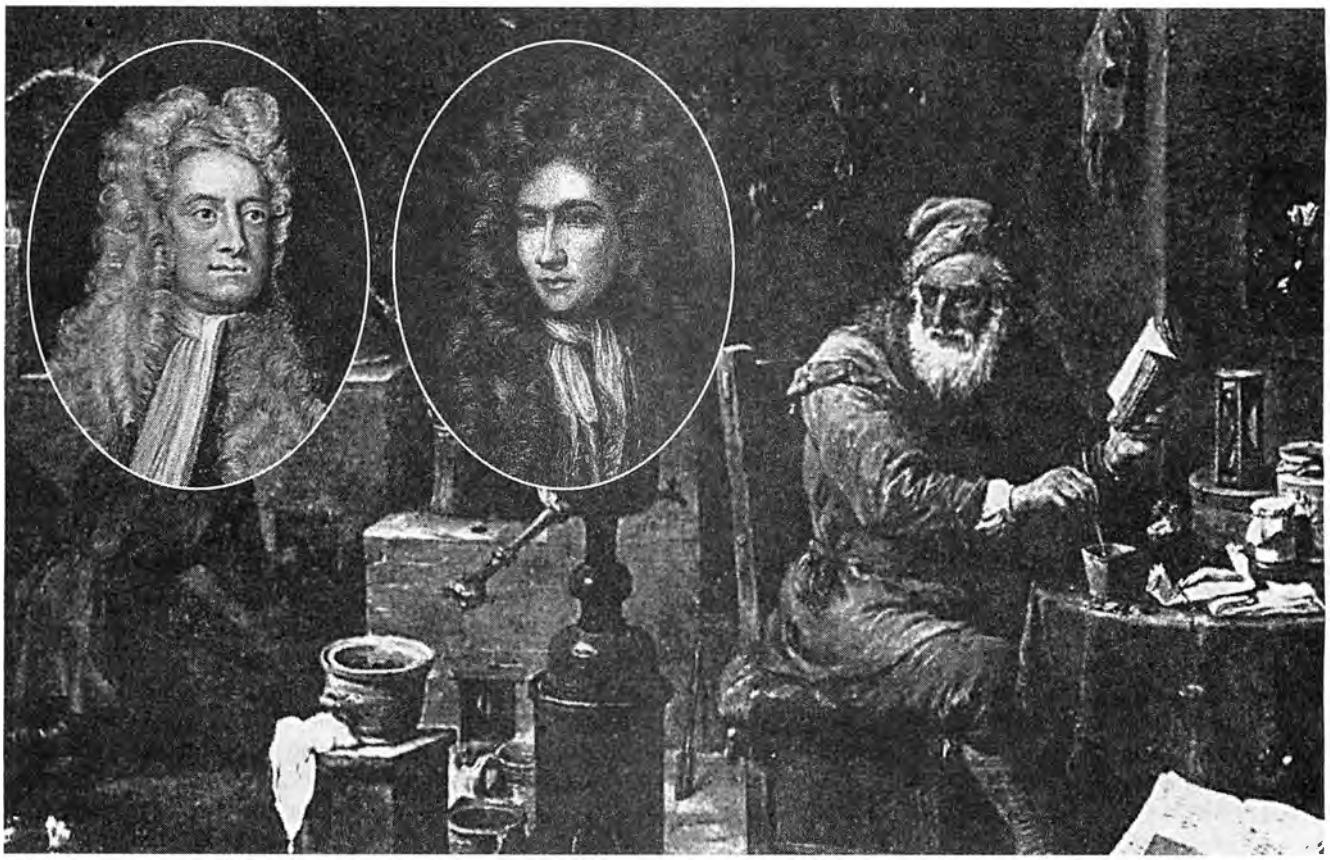
Finally, while Pierre is on a secret mission ordered by the Asters, a "Mr. la Marche" conveys to Boyle some unsettling news, creating "strange fears" in Boyle. Pierre then writes to explain to Boyle that la Marche is not to be trusted. La Marche, it seems, was suspicious of the assembly of Asters, and had written to Louis XIV, who had sent spies to the assembly and "dispersed most of the Cosmopolites." But the "guard of the magazine in the castle of Herigo . . . blew up . . . more than thirty of our masters."

No story was too incredible, it seems, if it included Louis XIV as the master criminal.

Boyle did not hear from Pierre again. Later, he learned that Pierre had taken Boyle's travel money, and gone to his home in Caen, France, not leaving there for the entire period of the correspondence (except to visit nearby Bayeux, where lives "a girl whom he got with child and for which the order of his arrest has been given"). Yet, this was not enough to dissuade Boyle. He was still working with "intermediaries" for the same Pierre up until at least 1685.

Unravelling the Bizarre

Principe visited Caen and found that the names Georges Pierre, du Moulin, and du Mesnillet all have connections to Caen and to each other, though not the ones that Boyle was told. Based upon Principe's research, one can assert that whoever created the story to lead Boyle on, had a knowledge of Caen, of alchemy, and of Boyle's circles and projects in England. However, a deeper investigation as to who and what was behind these games would most likely find the source of the al-



Arttoday.com/*Compton's Pictured Encyclopedia*, Vol. 2, 1928

Artist's depiction of a gold-making laboratory in the Middle Ages. Insets: "Highly suggestible subjects" Boyle (right), Newton (left).

chemical games deeply intertwined with the Venetian manipulators of the cultural and religious tensions of the time.

A few salient points:

(1) Caen was a hotbed of Protestant activity in largely Catholic France.

(2) The Venetian manipulations of Catholics and Protestants in France and England were quite intense in this period (including the 1678 Titus Oates frameup of Catholics in England, the 1683 Rye House kidnapping plot in England, the 1685 expulsion of Protestants from France, the 1688 Protestant overthrow of James II by William or Orange, and so on.

(3) The supporters of Boyle and Newton were heavily involved in all of this (including Bishop Gilbert Burnet and Lords Montagu, Essex, Monmouth, and Russell).

(4) A key intermediary between Boyle and Pierre was a Mr. le Moine, a doctor of medicine from Caen, and resident of London from no later than 1675, registered at the French Protestant Church of London.

(5) Le Moine was still with Boyle, when Bishop Burnet's special agent, Fatio de Duilliers, came to Boyle in the late 1680s.

(6) Burnet was the honored special witness for Boyle's prized transmutation experiments.

(7) Burnet, as the key agent for the anti-Catholic provocations that brought William of Orange to power in 1688, had recruited Fatio as the key witness for the allegation that Louis XIV was going to kidnap William of Orange.

(8) Fatio is the source of French alchemy books for Newton, probably including the one by Luigi dé Conti, which Newton did own.

(9) The Venetian Conti's book was published in Paris in 1678, making him at least one Adept active in Paris at the right time.

(10) Whether or not Luigi was a blood relation of the Antonio-Schinella Conti who ran similar games around Isaac Newton, circa 1715-1725, they ran on parallel tracks, and their common methodology was Venetian (via Paris).

He and Fatio de Duilliers were specialists in waving around "Louis XIV Antichrist" stories, to push targets in a certain direction. Fatio himself led Camisard disruptions in London in 1707, by millennialists who were convinced that Louis XIV was the Antichrist, and the world was shortly to come to an end. It would not be surprising if the loyalties of Boyle's controller, Burnet, were to the same forces that controlled Luigi dé Conti (and others), and who had sent Fatio de Duilliers in Burnet's direction.

Whether these circles actually believed that there were secret weapons of science to be obtained by the 1678 Boyle operation, for example, is not so shocking considering what else these circles delved into.

Bad Religion, Bad Science

Boyle and Newton were both highly suggestible subjects for such devilish operations. Principe concludes his arguments by dealing with Boyle's lifelong obsession with the supernatural: "No real understanding of Boyle is possible without an understanding . . . of his sincere religious dispositions . . . [A]naly-

The Other Conti Operation

In 1715, Antonio-Schinella Conti inserted himself into a high-level mission between the new governments of France and England. Gottfried Leibniz had, potentially, significant influence at both courts, amid heavy measures to keep him out. In France, Louis XIV had just died, and the Duke of Orleans had become the regent. Leibniz had recently written for the chief minister of the Duke, Nicolas Remond, an "elucidation of monads" (later titled *The Monadology*). Remond's older brother, Pierre Remond, travelled to the new Hanover court of England, along with Antonio-Schinella Conti. In England, the future queen, Caroline, Princess of Wales, was at that time a student and correspondent of Leibniz.

Conti offered to Leibniz to defend him from the nasty political attacks of the British establishment, and to mediate between him and Newton. Leibniz soon became suspicious of Conti, saying that he was a "chameleon" who was suffering from being away from the healthy air of Europe, having imbibed too much of the "atoms and void of England."

Leibniz had sent Newton a mathematical problem related to the development of the calculus, as was his open method of settling disputes. What he received in return was a stand-in for the impaired Newton, Dr. Clarke, who attempted to defend England from Leibniz's charge that "Natural religion seems to decay very much. . . . [Further] Sir Isaac Newton and his followers have also a very odd opinion concerning the work of God . . . [namely, that he intervenes whenever his clockwork universe breaks down]. I hold that when God works miracles, he does not do it in order to supply the wants of nature but those of grace. Whoever thinks otherwise must needs have a very mean notion of the wisdom and power of God."

The Leibniz-Clarke letters begin as such.

Antonio Conti proceeded to ingratiate himself with Newton, and he obtained some of Newton's bizarre curve-fitting calculations of historical events, bent to fit his twisted Biblical studies. Despite exhortations from Newton to keep such writings secret, Conti had them published in 1725, giving the embarrassed Newton reason perhaps to sympathize with the victimized Boyle of some 40 years earlier.

—David M. Shavin

ses of Boyle miss the mark whenever they fail to give preeminence to his devotion to orthodox biblical Christianity. . . . God is a wholly Free Agent in Boyle's voluntarist theology; He could act as He wished in both theological and natural realms. . . . Christ and the Apostles worked miracles. . . for the eyewitness Evangelists testify to the fact; the Philosophers' Stone transmutes lead into gold in an instant, whether or not we have seen it, for eyewitnesses testify to it."

Although religion and science are both crucified in Principe's treatment, his defense of Boyle does expose Boyle's sickness. A god that is radically free to do rational or irrational, good or evil, is indistinguishable from the devil.

Both Boyle and Newton had learned from writings of John Dee and Elias Ashmole that obtaining the magical "red powder" is interlinked with communing with spirits; that the Philosophers' Stone (which can make pure gold) also can "command and converse with Spirits." Further, Boyle had written in his 1665 "Excellency of Theology," that "many have chosen rather to venture the putting themselves within the power of Daemons, than remain ignorant whether or no there are any such Beings: As I have learned by the private acknowledgements made me of such unhappy (but not unsuccessful) Attempts."

Later in his life, Boyle unburdened his tortured self to his chosen alchemical witness, Bishop Gilbert Burnet, in what is called the "Burnet Memorandum." It is intermixed primarily with accounts of alchemy and of spirits. As Principe notes, "The 'Burnet Memorandum' reveals Boyle's tortured position of being powerfully drawn to supernatural or magical practices . . . yet fearful of the possible spiritual perils involved."

He goes on to argue that the more success that Boyle could have with his materialist science, the less room in creation is left for the Creator; hence, "we find Boyle particularly interested in topics that might straddle this divide: miracles, witchcraft, and, above all, his peculiar brand of spirit-tinged alchemy." For Principe, "Robert Boyle was above all other things a Christian," funding Bible tracts, translations, and Joseph Glanvill's mission to verify witches. He would also have us believe that science and alchemy are neither as new or old as we think, but are really, fundamentally, the same.

Poisoning

It is somewhat ironical for Principe to suggest that "Boyle's own chronic sickness" and Newton's "well-known mental illness" might have resulted from "acute mercury poisoning—the kind of poisoning that might very well follow from the multiple distillations and digestions of mercury necessary in Boyle's Mercurialist process." (He even cites the "exceedingly high levels of the toxic substance [mercury] found by the microanalysis of Newtonian hair samples.")

There is a reason the Hatter is called Mad. The fumes that hatters worked with, it is suggested, had deleterious effects upon their reasoning capacity. Going through the Looking Glass does not exempt one from actual cause and effect.

In the final analysis, should the reader be more concerned about Boyle's problems or Principe's? Is this a 300-year-old story, or one that today we have yet to surmount? Gottfried Leibniz most famously and properly treated these matters, in the 1715-1716 Leibniz-Clarke letters, by diagnosing the "scientific" problems of Newton and the British Royal Society as fundamentally theological problems.

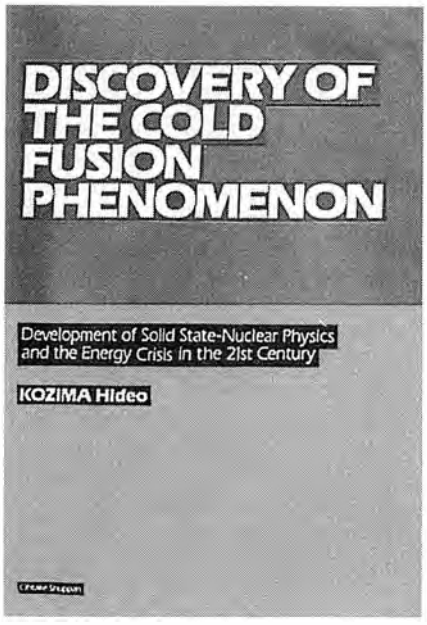
My recommendation: If you choose to read *The Aspiring Adept,* treat it as a morality play, follow it with a shower, and have a copy of the Leibniz close by.

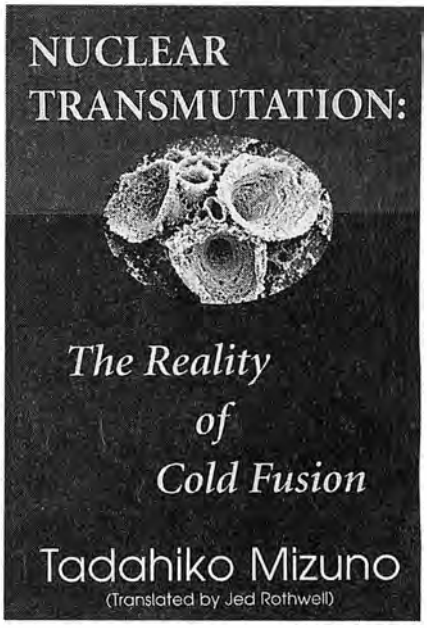
Cold Fusion: Theory and Practice in Japan

by Dr. Edmund Storms

Discovery of the Cold Fusion Phenomenon
Hideo Kozima
Tokyo: Ohotake Shuppan, 1998
Hardcover, 370 pages, $60.00

Nuclear Transmutation: The Reality of Cold Fusion
Tadahiko Mizuno
Concord, N.H.: Infinite Energy Press, 1998
Hardcover, 151 pages, $32.95





Cold fusion remains one of the great controversies in modern science, perhaps on a par with the experience suffered by Galileo, or initially by Darwin. Two new books on the subject have now been added to the seven already available.[1-7]

The first of the pair, *Discovery of the Cold Fusion Phenomenon,* by Hideo Kozima, comes to the subject from the viewpoint of a theoretical physicist who has a favorite explanation. It is much like a very long scientific paper in which the author has the freedom to explore every nuance of his unique insight.

Prof. Kozima, of Shizuoka University, Japan, avoids many conceptual problems, while creating a few new ones, by proposing the existence of quasi-stable trapped neutrons within a solid atomic lattice. These neutrons interact with various nearby nuclei when the conditions are just right. Other scientists have found experimental evidence and theoretical reason to suggest that these neutrons result from a shift of the electron that orbits hydrogen to an unusual orbit very near the nucleus.[8-11] This electron-proton couple acts much like a neutron and perhaps interacts with other nuclei as described by Prof. Kozima. Of course, this latter idea violates current theory based on quantum electron dynamics and will, no doubt, add to the enthusiasm for rejecting the whole field.

The second book, *Nuclear Transmutation: The Reality of Cold Fusion,* by Prof. Tadahiko Mizuno, of Hokkaido University, Japan, is a personal travelogue through the intellectual and political minefield of this field. Prof. Mizuno reveals himself as a very careful and patient experimentalist, who gradually improved his methods and insights while contributing much of the required funds from his own pocket. If only conventional science rewarded such dedication to unique discoveries, we would all be much better for the effort.

Prof. Mizuno's odyssey began during a routine experiment to study how palladium would react with deuterium. Upon turning off the electrolytic cell, he found that the steel container refused to cool. In fact, 37.5 liters of water were vaporized over several days before its temperature returned to a normal value. Simple calculations show an energy release much greater than any possible chemical reaction or heat storage mechanism. Other cells, which were being used to prepare targets for a study of how neutrons interact with various metal deuterides, also occasionally showed strange heat and X-ray production.

Because Stanley Pons and Martin Fleischmann had not yet made their announcement, these amazing observations were ignored—but they got Mizuno's attention. When "cold fusion" briefly became a household word, he remembered this experience and undertook a study of the effect with enthusiasm. Mizuno was one of the few people in the world at that time who had experience in preparing metal deuterides by electrolysis and who had access to good radiation detection equipment.

After several false starts and much effort, he was the first to show that the cold fusion reaction produces neutrons, although many fewer than conventional theory would predict. Although this success has been replicated many times since, it took some significant courage to report the results at the time.

Tritium generation was the next anomalous result to be seen. The absence of neutrons and the presence of so much tritium was so unexpected that Mizuno was as bewildered and doubting of his results as everyone else. Indeed, skeptics today are not unique in their questioning attitude—they just choose to ignore what other people choose to believe.

Excess Energy

Excess energy was the next of the original claims to be duplicated. After satisfying himself that the Pons-Fleischmann claims were correct, he set about to explore other chemical environments. Proton conductors (ceramic materials that dissolve hydrogen that can be caused to diffuse with the application of a small electric current) were made to produce excess energy after a year of trial-and-error effort. These results were recently

duplicated after many failures, at the University of Minnesota.[12]

Then, to add to the drama, Mizuno sought and found evidence for many other nuclear reactions besides fusion, thus the title of the book. The more he and his colleagues looked, the more elements having unusual isotopic distributions were detected. Such elements cannot result from normal material sneaking into the apparatus, but must be made in place by some unusual processes. Conventional scientists shout, *Impossible!*

Indeed, if this were the only evidence for the effect, we might well dismiss the work, as did Dr. Robert Park of the American Physical Society recently in one of his amusing weekly diatribes.[13] However, evidence for transmutation is being obtained regularly in many laboratories around the world by those scientists who take the trouble to look. Only a fraction of the available papers are listed here.[14-25] Of course, it is easy to take the coward's way out and reject new ideas without bothering to see the evidence. Fortunately, these books show that people with intellectual courage still exist in science, and that they continue to explore cold fusion in spite of righteous condemnation by their peers.

Both books are worth reading to see how science should be practiced and how far modern science has drifted from its roots. Although this issue is important, it is not the most important one. Mankind is destined to run out of energy supplied by fossil fuels. Timing is a matter of debate, but the end is a certainty. Nuclear energy was expected to provide a long-term substitute. We now all know why this has not happened. Hot fusion was offered as the unlimited and pollution-free solution. Unfortunately, this method has proven to be too difficult for scientists to solve any time soon.

Then, out of the blue comes cold fusion. Rather than being welcomed as our salvation, the idea is rejected with enthusiasm at all levels of science and government. An objective person might well ask why, and then wonder at the insanity this rejection represents.

Edmund Storms reviewed the status of cold fusion in 21st Century, *Winter 1998-1999, p. 14.*

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Exploring Planets Known and Unknown

by Matthew Moriarty

Worlds Without End:
The Exploration of Planets Known and Unknown
John S. Lewis
Reading, Mass.: Perseus Books, 1998
Hardcover, 236 pages, $24.00

Imagine if there were no Moon to light our night sky. Would we still dream? Would the gray goose find its way to distant breeding grounds? Would the oceans lie silent against our shores? Imagine further, what if our Earth were somehow smaller, less dense than it is now; or imagine again, if it were larger. Would the spring winds be more gentle, or relentless harbingers of endless foul weather? What if the Sun burned a little brighter, or more dimly? Would the winter snows never fall, or would endless ice storms war against the Earth and the possibility of life?

Indeed, if the Sun were fickle in its output, like so many of our stellar neighbors, could life have evolved and survived on Earth at all? In this "best of all possible universes," could life have evolved anywhere else in our solar system? Imagine, if you will, other worlds in other solar systems. Imagine, if you can, the myriad possibilities for life not here, but out there among the stars. What conditions must exist to sustain life beyond this Eden, on worlds spellbinding in their sheer strangeness and diversity?

Imagine worlds without end, and in doing so, you will have come close to doing what author and planetary scientist John S. Lewis has done in a wonderful new book with the title *Worlds without End, The Exploration of Planets Known and Unknown.*

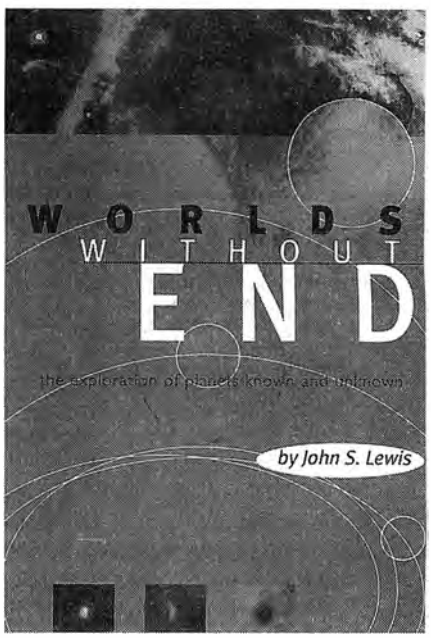
The timely appearance of Professor Lewis's new book coincides with recent breathtaking discoveries of planetary objects orbiting a host of nearby stars. Since the discovery, in 1995, of the first extrasolar planet, a companion to 51 Pegasi (star 51 in the constellation Pegasus), 16 other planets circling other nearby stars have been confirmed—at least, insofar as current technology allows. These planets are not Earth-like, holding a prospect for supporting life as we know it, but all are massive bodies, comparable in size to our solar system's gas giants. The companion to 51 Pegasi is within 44 to 60 percent of the mass of Jupiter, while that of HD168443 is more than five times the mass of Jupiter! Massive sizes, as Lewis explains, narrow considerably the prospects for sustaining life, and when combined with unfavorable orbital characteristics, which many of our new family of planets possess to an astonishing degree, all but eliminates the possibility.

Why have we found no Earth-size planets, orbiting at comfortable distances from their respective stars? The answer is in the technology of planetary discovery. We simply do not yet have the telescopes or detection technology to do so. Planets are feeble reflectors, and therefore too faint to be seen against the background light of their parent stars. With one possible exception (the case of protoplanet TMR-1C, recently photographed using the Hubble Space Telescope), our new discoveries remain hidden from view.

In language easily accessible to the nonscientist, Lewis explains the various methods used to detect and confirm the existence of extrasolar planets. These methods have not always inspired agreement that every alleged find is, indeed, a new planet. Some discoveries, like 51 Pegasi b, were heatedly disputed in the early days of planetary detection. And there are at least five or six candidate planets about which the information is too weak to say with certainty that they are indeed planets. It will take new and improved technologies before we know for sure.

Planet Discovery

The most successful method for discovering planetary systems outside our own solar system remains the so-called radial velocity method. This procedure, while simple in principle, requires a good deal of experience, since so much of the inferential work—leading to a conclusion that a star has a companion---depends on the precision of these velocity measurements.



Briefly explained, a planet's orbital motion about its star causes a periodic motion of the star around a common center of gravity. This motion, Lewis explains, causes a detectable shift in the wavelengths of the lines in the star's spectrum. If the ratio of the mass of the companion to the star is large, this shift in wavelength, called a Doppler shift, will be large. But a large Doppler effect would also occur if the companion, because it was orbiting close to its parent star, had a high orbital velocity.

Thus, the radial velocity method is especially good at detecting massive planets with close-in orbits. The first such discovered planet, 51 Pegasi b, is only .05 AU (astronomical units) from its star. (One AU is the Earth-Sun distance.) The star Tau Boötis's companion planet has a mass estimated at 3.87 Jupiters, but, unlike our distant gas giant Jupiter, which resides 5 AU from the Sun, this companion has a 3.3-day orbital period and is as close as .046 AU from its star. In fact, more than half of the newly discovered planets are less than 1 AU from their respective stars. Lewis laments that it may be years before Jovian giants can be de-

tected orbiting at distances comparable to those in our solar system.

For any of the recent Jupiter-like discoveries can we imagine conditions suitable for life? No, for them, life is not likely, Lewis says, at least not for biologically significant periods of time. Even if we imagine suitable ecological niches in cloud layers warm enough to support liquid water, atmospheric turbulence would mix these layers with freezing currents at higher levels in the atmosphere, where even the simplest organic molecules would be ripped to shreds by the intense ultraviolet radiation. Convective forces would also carry these same water-filled layers down deep into the lower atmosphere, subjecting organic molecules to destructive temperatures of thousands of degrees and pressures of thousands of atmospheres.

It might not be possible to completely dismiss the possibility of life existing on a Jupiter-sized planet, but imagining its chemistry and origin requires comprehensive knowledge of planetary composition, mass and geology, orbital inclination and distance, eccentricity, type of star, and so on. Throughout this wonderfully detailed book, Lewis informs the reader in a way that prepares him to see conclusions as reasonable consequences of physical laws. We not only need to have the right conditions for life to appear on a planet, but these conditions must endure over many millions of years.

Touring the Solar System

One of the more interesting, albeit minor, speculations contained in *Worlds Without End,* concerns the Earth-Moon relationship. Could we imagine life on Earth without the Moon? It is probably true, as conventional theory holds, that the Earth-Moon relationship began early in the history of the solar system, but not before Earth and most of its planetary siblings had already formed out of the solar nebula. In fact, hundreds of millions of years would pass: time for Earth to cool, form a crust, evolve an atmosphere of sorts, and form deep basins and high mountains. Indeed, there would have been time enough for the Earth to have formed vast oceans, where some form of primitive life could have existed—life with an evolutionary path different perhaps from that with which we are familiar. Speculation? Yes, but a reasonable speculation, based on the Earth's probable mass and compositional differences at that time.

We can be sure that before the Earth had a Moon, axial inclination, rotation rate, and orbital eccentricity—all features that affect climate and habitability—were different in significant ways. The giant impact theory postulates that at one point, a Mars-sized (6,000 km) body collided with the Earth. The resulting impact, Lewis proposes, would have been 200 million times more lethal than the Cretaceous impact that wiped out 70 percent of life on the planet, having more than enough energy to completely boil off Earth's oceans, melt more than half the crust, and send huge sprays of molten rock into high orbit. The core of the Mars-like intruder is stopped on impact, but sinks deep into the Earth's own core, changing its composition, while adding mass and heat.

Much of the debris splashed out into space rains back on Earth, heating the atmosphere to thousands of degrees, but some of it remains in orbit, cooling and gradually clumping together, becoming more efficient at clumping as it grows larger. As the Earth itself cools, re-forms a crust, builds anew its oceans, the Moon has swept up nearly all the debris in its path, but it is much closer to the Earth than it is now, and the tides it produces are towering. The pull of the Moon on the Earth drags against its spin, slowing down the Earth's rotation rate and gradually lengthening the day.

The loss of angular momentum allows the Moon to inch outward to an ever more distant orbit. In the far distant future, the Moon may eventually escape Earth's gravitational hold and freely and dangerously pursue its own course around the Sun. Quite a dramatic picture.

It is in this vein that Lewis takes the reader on a brief, but grand, tour of the solar system. There are so many fascinating observations here that the reader will want to go over them again and again. We learn that Mercury rotates on its axis three times for every two revolutions in its orbit about the Sun; that the interior core temperatures of Jupiter are hotter than the surface of the Sun; yet temperatures in the upper cloud layers reach −236° F. We learn why Mars cannot have many volcanoes, but also how it is possible that the two or three it does have are so huge (up to 17 miles high)!

In a chapter titled "A Suite of Earths," Lewis takes the reader along on an imaginative journey to Earth-like planets. He asks: How would an Earth-like planet—a planet with the same general composition of minerals, gases, and so forth—have evolved, if the mass and size of the planet had been significantly smaller, or larger? The reader will be fascinated by carefully reasoned arguments that build plausibility into these worlds. There is another chapter titled "Planets Around Planets" that examines, without burdensome detail, the chemistry and composition of the larger Moons in our solar system. Lewis's interest here is their suitability for harboring some form of life.

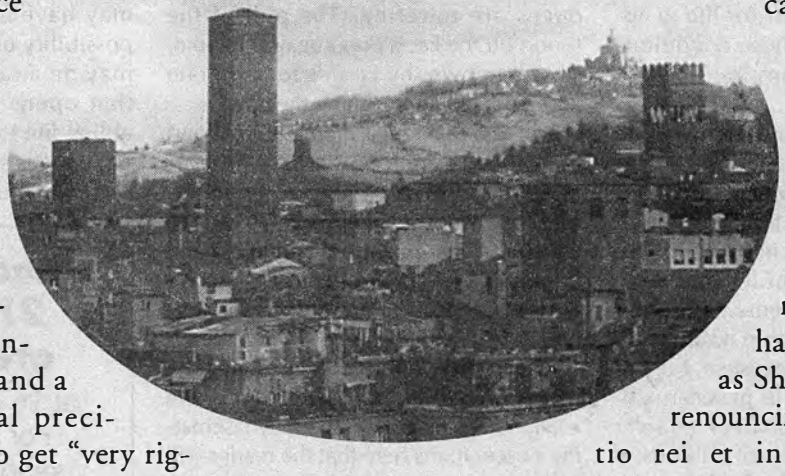
Worlds Without End makes planetary science exciting, while at the same time insisting that the reader pay attention to the complex interplay of planetary and solar composition and mass, as well as orbital characteristics, such as inclination, eccentricity, and so on. Lewis shows us that while life has specific requirements beyond the obvious availability of nutrients and comfort, it must also have some degree of long-term stability to prosper. Subtle changes in solar output, small differences in mass and composition of a planet, slight changes in eccentricity and axial tilt, may have a dramatic impact on the possibility of life. Yet, paradoxically, it may be a random catastrophic event that opens up new possibilities enabling life to get on its way. My imagination was stimulated by *Worlds Without End.* Yours will be too.

International Conference
Galileo Back in Italy—II

For the Return of Rationality in Modern Physics

In spite of great technological success, physics at the end of the century has come under more and more criticism. It is charged with having lost its character as an experimental science, becoming too abstract and mathematical.

P.K. Feyerabend considers this science mostly "very dull, and more deceptive than that of the 16th or 17th centuries was." R. Thom remarks that in it there is a horrible mixture between incorrect fundamental concepts and a fantastic numerical precision," pretending to get "very rigorous numerical results from theories which conceptually are nonsense."



The unquestionable practical success of physics has actually minimized the critical interest in fundamental postulates and their interpretation, so that there is a whole series of conceptual riddles which force a re-examination of the foundations of physics today.

Roughly speaking, these fall into two great schemes: the relativistic, and quantum theories. In both, the common notions of space, time, and causality are so deeply modified, that a whole new philosophy has been built in order to support the view that Nature cannot be explained by classical principles of rationality, built upon the three intellectual categories.

As Nobel Prize winner R.P. Feynman asserts, one has to "accept Nature as She is: absurd." The renouncing of the "adaequatio rei et intellectus," which should be the primary aim of any scientific research, has led to the result that the great majority of physicists have lost all hope of being able to understand Nature. Instead, an unpleasant kind of resignation has taken over.

But a critical reaction is developing. Criticism of the "Copenhagen Interpretation" of quantum mechanics had begun already in the 1970s; that of

"special" relativity has endured since 1905, but it was always vehemently and systematically suppressed, to the point that this theory has now become "the holy of holies" of modern physics. But the very success of Einstein's point of view has insinuated into the heart of physics, the arbitrary definitions typical of modern formalistic mathematics with its presumption of being free, in its conceptual foundations, from any kind of intuition.

Furthermore, the disappearance of the concept of an ether as a result of the Einsteinian "solution" of electromagnetic problems, has made it impossible to prove that in the physical properties of "empty space" there might be an argument against the claims of inexplicability of microphysical phenomena.

We ask all scientists who find some reasonable elements in the above, to take part in the international conference, which will take place in Bologna, Italy, May 26-28, 1999.

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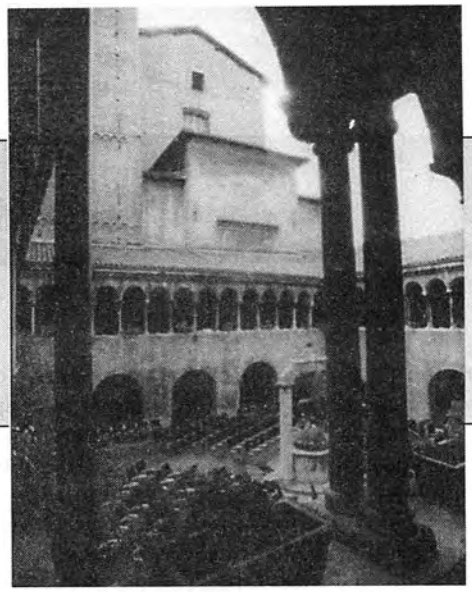

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Maui's Voyage

Continued from page 74

in 1937-1938 by an ethnography expedition led by Josef Röder from the Frobenius Institute at the University of Frankfurt, Germany. The Röder group photographed the drawings, and later Röder published them, but they were not deciphered until Fell was able to do so in the 1970s. Maui's astronomical calculations and observations, including that of a solar eclipse and a comet, enabled Fell to date the drawings to 232 B.C.

Maui's Sky Map

Maui's drawings, apparently made a few months later in the journey, in another cave on Wamera Island, off the southeast coast of New Guinea, date from around November 232 B.C. They depict a map of the constellations at that time, and indicate the sophistication of his (and Eratosthenes') astronomical knowledge.

Fell comments that as the flotilla entered the Southern Hemisphere, Maui noted the recession of the familiar northern zodiacal constellations at that season, and the ascendancy of the six southern ones.

Fell writes: "One other striking alteration—no doubt predicted by Eratosthenes before the fleet sailed from Alexandria—was that for the first time, men from the Northern Hemisphere saw the constellations overturn, to hang upside-down in unfamiliar attitudes. Taurus, which had always been to the left of Aries, now lay to the right, and Cetus overrode the pair, whereas hitherto that monster had lain deep in southern declination. For an astronomer such as Maui, no more convincing proof could have been given that the Earth is indeed a sphere, and that Rata's ships were now sailing 'upside-down' with respect to their sister ships in far off Libyan waters. The triumphant demonstration of Eratosthenes' theories was recorded one day when the fleet put in at Wamerei [Wamera] Island. . . ."[3]

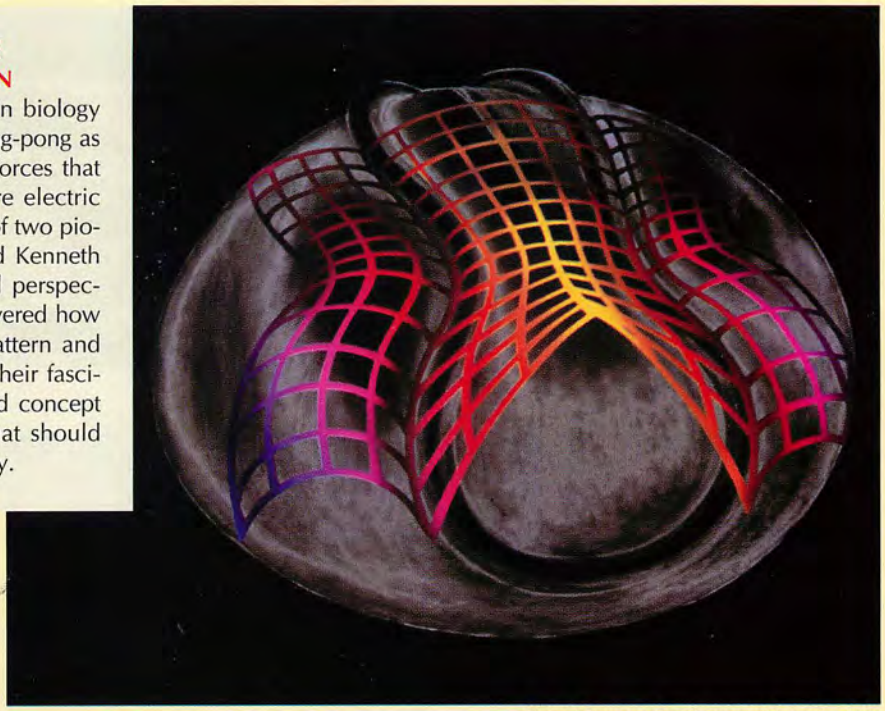
Maui's sky map, showing the region of Aries and Taurus, was painted in white on the wall of the Wamera Island cave and is shown, along with Fell's interpretation, in Figure 1 (p. 74). The 30-cm map contains a landmark, a node (area marked 1 in the figure) for reckoning right ascension, which, at that time was in the constellation Aries. (Right ascension is still reckoned from that point in Aries, although the node itself is in Pisces, 30° west of where it was in 232 B.C.) This intersection, noted by Maui, is where the celestial equator crosses the ecliptic. When the Sun passes through this point, called the ascending node, it marks the beginning of spring in the Northern Hemisphere, and is known as the vernal equinox. (See Figure 2, p. 75.) All of Maui's sky maps depict the ascending node.

Notes

1. "The Decipherment and Discovery of a Voyage to America in 232 B.C.," by Marjorie Mazel Hecht, *21st Century*, Winter 1998-1999, p. 62; "Indian Inscriptions for the Cordilleras in Chile, Found by Karl Stolp," (1885), *21st Century*, Winter 1998-1999, p. 66. See also, this issue, p. 29, for the decipherment of Maui's proof of Eratosthenes' measurement of the circumference of the Earth.
2. For more information, contact the Epigraphic Society, Donal B. Buchanan, Secretary, 8216 Labbe Lane, Vienna, Virginia 22182-5244, or e-mail donalb@ aol.com.
3. Barry Fell, 1975. "An Ancient Polynesia Star Atlas of 232 B.C.," *The Epigraphic Society Occasional Publications*, Vol. 2, No. 30 (Feb.).

ELECTRIC FIELDS MOLD THE EMBRYO'S GROWTH PATTERN

Contrary to the reductionist direction in biology today, which emphasizes molecular ping-pong as the basis of living systems, the actual forces that control development of the embryo are electric fields. Colin Lowry describes the work of two pioneering scientists, Richard Borgens and Kenneth Robinson, both trained in an historical perspective of science and biology, who discovered how electric fields determine the growth pattern and differentiation of cells in the embryo. Their fascinating research has created a new field concept of development, which is the route that should lead to the next breakthroughs in biology.



Richard Borgens, *Developmental Dynamics*, 1995

Artist's reconstruction of the topography of electric fields in an early amphibian embryo. The superimposed color graph represents the intensity of the voltage potential at the surface of the embryo during neurulation.

A 3RD CENTURY B.C. ASTRONOMICAL CALCULATOR

One of the tantalizing pieces of evidence of the advanced transoceanic seafaring capability at the time of Eratosthenes (c. 275-194 B.C.), is the cave drawing by Maui of his *tanawa* or calculator, which helped to guide the journey of an Egyptian flotilla around 232 B.C., in its mission to circumnavigate the globe. In the Ancient Discovery section, Sentiel Rommel, who worked with marine biologist and linguist Barry Fell in the 1970s, describes his reconstruction of the tanawa, and Marjorie Mazel Hecht reports on Fell's translations of Maui's astronomical cave inscriptions.

© Barry Fell, *America B.C.* (New York: Simon & Schuster, 1976), p. 118.

Drawing by Maui of the tanawa, found in a cave on Wamera Island, off the coast of southeast New Guinea.

ANTINUCLEAR RED-GREEN ALLIANCE ON THE WAY OUT IN GERMANY?

The German government announced in late January that it had dropped plans to eliminate the use of nuclear technology, one of the main policies of the ruling Social Democratic Party and Green Party (the Red-Green alliance). And after further pressure from labor unions and industry, German Environmental Affairs Minister Jürgen Trittin announced in February that his new technology bill no longer contained the proposal to ban all nuclear reprocessing in January 2000. In the Nuclear Report, Rainer Apel describes the government's retreat under pressure, the ailing Red-Green alliance, and the happy resurgence of a pro-nuclear fighting spirit.

Patriots for Germany

In the 1980s, the Patriots for Germany and Fusion *magazine, both affiliated with the LaRouche political movement, supplied the pro-nuclear fighting spirit against the eco-terrorist assault on nuclear energy.*

In This Issue:

VOYAGES OF DISCOVERY

Transoceanic voyages of discovery in ancient times are usually thought to be impossible. Yet, we know that they occurred, and we know that there is evidence of prehistoric maritime cultures with advanced astronomical knowledge. This issue's three-part cover story considers different aspects of such voyages and what they entailed.

NASA

Artist's illustration of the International Space Station.

- Lyndon LaRouche looks at the principle of discovery, its relationship to classical art and classical physical science, and the impassioned mental process behind it. He poses the challenge of reviving this passion for truth and justice today.
- Gabriele Liebig examines the purpose of Homer's *Odyssey* within the Greek Renaissance in the 8th century B.C., and the riddle of where it took place. She presents evidence that Odysseus was not confined to the Mediterranean Sea, but was journeying in the unknown Atlantic.
- Marsha Freeman takes up a modern journey of discovery—the Space Station Mir—and the challenge to travel throughout the Solar System. Like all great voyages throughout history, she says, this requires a scientific plan, great resources, and may entail great risk.

Continued on inside cover

Erich Lessing/Art Resource N.Y.

The Sirens tempting Odysseus (front cover), in a Roman mosaic, 3rd century, from the National Museum du Bardo in Tunis, Tunisia.