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NASA photo of Astronaut Daniel T. Barry, mission specialist, traversing the Space Shuttle Discovery's payload bay Aug. 16, 2001, with Earth in the background.

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21st CENTURY SCIENCE & TECHNOLOGY

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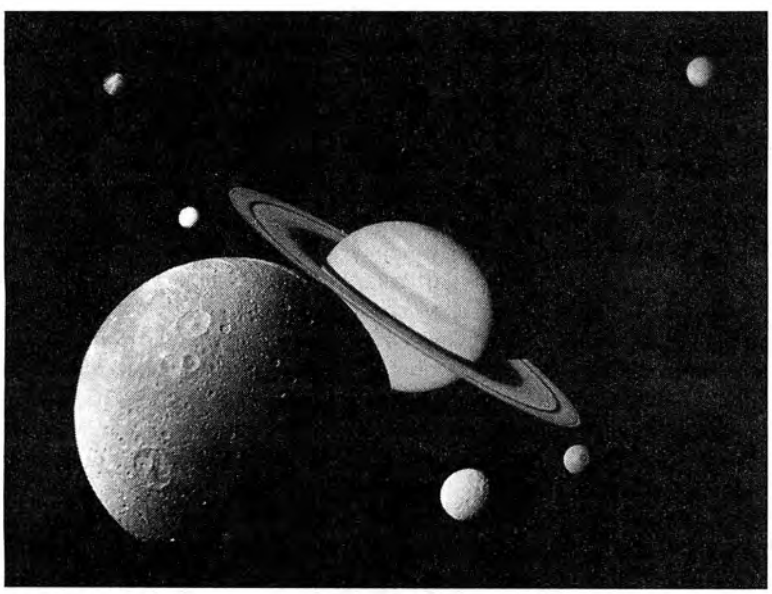
Features



NASA montage of Saturn and some of its Keplerian system of satellites, prepared from images taken by the Voyager I spacecraft in November 1980.

In a first-ever English translation (p. 27), the founder of modern astronomy, Johannes Kepler, charges Aristotle with holding science back for two millennia by his specious arguments against the heliocentric system already known to the Pythagoreans in ancient Greece.

News

Departments

On the cover: The latest design for the International Thermonuclear Experimental Reactor (ITER), in cross-section. The human figure in the right foreground indicates the size of the fusion reactor. Illustration courtesy of the International Atomic Energy Agency; cover design by Alan Yue.

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Leibniz, Vernadsky, LaRouche

In order for there to be composite substances, there must be simple substances, that is, without parts, to make them up. Where there are no constituent parts, there is possible neither extension, nor form, nor divisibility. These simple substances, without length, mass, or time measure are called by G.W. Leibniz *monads,* "the true Atoms of nature, and, in fact, the Elements of things."

An appreciation of the problem of how to integrate the necessary existence of monads into a study of the visible, or measurable, parts of nature has been the mark of all competent science, since classical times. Our most direct knowledge of the monad comes from examination of the mind in the process of invention, or discovery of a fundamental principle of nature. In this case, the subject is the higher form of monad, also known as soul, which uniquely characterizes the human species.

In the early part of the 20th century, the great Russian biogeochemist Vladimir Vernadsky was able to recognize an ordering in man's understanding of nature according to three distinct yet interacting realms of action in the universe—the abiotic, the living (biosphere), and the cognitive (noosphere), each one able to act upon the successively lower realms in a hierarchical but also multiply connected fashion. In particular, Vernadsky recognized the unique capability of the cognitive to exert power over the non-living, and also the biosphere.

In a conceptual breakthrough which he dates to approximately 1948, Lyndon H. LaRouche, Jr., came to a conception of the relationship of the cognitive to the abiotic and living processes, which goes a step beyond that of Vernadsky. LaRouche saw, in his studies of physical economy, that economic value is determined solely by the discovery and realization through society of unique, new discoveries of physical principle. In this process, the individual mind, a Leibnizian monad, conceives an "object" of no particular, mass, length, or measure of time. This "object," also a type of monad which Plato called the Idea, then has power to reshape the entire relationship of the human species to the Earth and the rest of the universe.

The difference with Vernadsky arises in LaRouche's recognition of the significance of the conditions necessary to produce such new ideas and to realize them. This places the question outside of any possible "objective" interpretation of nature, into the realm of language, culture, and universal history, where the influences shaping the possibility of development of new ideas that transform nature are to be found.

A Scientific Dialogue

The importance of such matters is recognized wherever science is practiced, and in Russia, particularly in the trying times of the past 10 years, profound discussion of such ideas has taken root. As we go to press, the news reaches us of an extraordinary conference and discussions, which took place recently around an event commemorating the recent death of an extraordinary Russian scientist, Pobisk Kuznetsov (1924-2000).

Kuznetsov was a universal thinker and innovator in many branches of science from photochemistry to the design of management systems for technical research. Much of his education took place in the Gulag. Professor Kuznetsov had become aware of LaRouche's writings in the early 1990s (during LaRouche's imprisonment), and hosted a visit of his fellow political prisoner to Russia in April 1994. LaRouche returned to Russia several times since, and most recently to attend the Dec. 14, 2001 memorial for Kuznetsov, among other important meetings. A flavor of the dialogue under way may be tasted in this excerpt from LaRouche's address to that event. We take up LaRouche's short speech at the point that he notes

Rachel Douglas/EIRNS

Physical economist Lyndon LaRouche addresses the Dec. 14-15, 2001 memorial in Moscow in honor of Russian scientist Pobisk Kuznetsov (1924-2001).

Vernadsky's proof of the *differentia specifica* of life:

"Now, Vernadsky, using the same methods of crucial, universal scientific proof, which had been used by Mendeleyev earlier, made a *conclusive* scientific demonstration of the distinction of the principle of life, on the basis of biogeochemistry, continuing the work of such predecessors as Pasteur and Curie.

"He also went further, and this comes to the question of what man should do about the biosphere. And I'll state the thing in my own terms, rather than exactly the way Vernadsky put it. What Vernadsky demonstrated (though I think not as conclusively as he would have wished to, had he lived longer), from the standpoint of physical science, is that man is made in the image of the Creator of the universe, and has special powers which no other creature has. This corresponds to a concept, first developed in known European civilization by Plato, in his dialogues. This is also a concept, which was developed in what are called 'spiritual exercises' in certain aspects of Christian theology. So, this power is known, and we have ways of demonstrating it, as Plato demonstrated it with the dialogues, and as theologians sometimes demonstrate it, as well.

"So, from Vernadsky's standpoint, with this background, the universe as we know it, is divided into three special kinds of interacting 'phase-spaces.' These are defined from the standpoint of experimental physics, as follows. We know certain principles, which can be proven experimentally, to be universal, from the standpoint of the assumption that the universe were abiotic—not a living universe. There are also experiments, as typified by the work of Pasteur, and Curie, and Vernadsky, that demonstrate that the abiotic universe is efficiently transformed by *a principle which exists entirely outside* the abiotic universe. This is the principle from which life-forms are generated, in the universe. This principle—'life,' if you wish to call it that—is apparently very weak, relative to abiotic forces, but its persistence on Earth demonstrates, that life has increasingly transformed this Earth, so that more and more of the Earth is either living processes, or the products of the action of living processes.

"Then we come to a third category: The power of individual human cognition, as expressed by the discovery of scientific principles, is also a force which acts upon all aspects of the universe, both the abiotic and the living, in the same way that the living processes act upon the non-living universe.

How Man Changes His Nature

"Now, what Vernadsky considered, but did not undertake, in his late work, on this subject, was a question which I found Pobisk [Kuznetsov] wrestling with, at the time I first met him: How can we represent a universe, which is composed of three concurrent, but distinct, phase-spaces? It was suggested to Vernadsky, but he didn't take it up—partly because of his age and condition, at that time. There is a unique mathematical-physical conceptual approach to this problem. It's called 'Riemannian geometry.' In particular, this geometry has a very specific name, of great significance, which is peculiar only to Riemannian geometry. That name is, 'differential geometry.'

"This is not exotic. It's very tangible, very demonstrable, but like all scientific facts, it has to be demonstrated, to be made clear. This is where Pobisk became fascinated with my definition of 'potential relative population-density,' as a function.

"So, the significance is this: What is the difference between man and an animal? An animal can not change his nature. Man does, we hope. How does man change his nature, in a positive way, of course? By making the equivalent of an hypothesis, which turns out to be *an experimentally provable, universal physical principle.* By our adopting these principles, as we discover them, and by our cooperating in using these principles, we increase man's power in the universe, per capita, *in the only way possible.*

"That is the secret. Therefore, if you wanted to have the best economy, if you want the kind of economy that can master the problems of the biosphere of Central and North Asia, you must change the policies of education, and qualification and employment of the labor force. You must make the educational process, including the university, the driver of the economy. You must get away from the textbook approach to education. You must burn all multiple-choice examinations. You must teach science the way it was developed: The pupil must experience the mental act of discovery, of the great discovery, from thousands, or hundreds, or tens of years ago. You must base the educational process on a heavy emphasis on *pedagogical experiments.* In

other words, the child must—or the child, or the adult—the student must experience the paradox, which shows that the present assumptions of knowledge are false. The student must somehow develop the experience of generating the hypothesis, which solves that paradox. The student must experience the pedagogical experiment, which is sufficient to test the hypothesis. And the process of pedagogical experiments must be extended, as a habit, into fundamental-research experiments, which should be the driving concern of the university.

"This must be a process, not merely of a few scientists; it must be the process of the entire population. You can not have a scientist directing, effectively, a scientific principle's implementation, to a bunch of working people who can't understand it. From my limited knowledge of Pobisk, if he were sitting here now, he would be laughing with pleasure, at what I am saying. . . ."

'Statecraft'

LaRouche's final point was that the idea that science is limited to what we call "physical science" is a great error. "What we should look at, is not the idea of physical science as such, but we should look at the condition of the mind, which generates, successfully, the great discoveries of universal principle upon which we depend." He gave two examples, from music and from classical drama, in which the skillful dramatist, who is also a student of universal history, such as Shakespeare or Schiller, develops the idea of a sublime character who can lead a nation out of a crisis to which it is otherwise doomed. Thus LaRouche concludes:

"So, in addition to this role of the scientist, who is also one of these sublime people, who lead nations out of potential failure, we must see physical science as simply one branch of a larger science, properly called "statecraft," in which the greatest Classical art is used to help a population educate itself in the kinds of institutions and cooperation that society must employ to solve its problems. That's why I'm a happy revolutionary. That's why I was able to recognize Pobisk as an essentially happy revolutionary: He had the essential quality of a great scientist—laughter."

More to come in future issues.

—Laurence Hecht

An Earth Scientist Appreciates Vernadsky

To the Editor:

In the Spring 2001 issue of *21st Century,* there is an interesting item on Vernadsky by Elizabeth Pascali, actually a review of a book, *The Biosphere,* translated by D.B. Langmuir (New York: Springer-Copernicus, 1998). From my own point of view, with a long-term fascination in the history of Earth Sciences, this review struck a responsive chord. I looked up Vernadsky (1863-1945) in the *Encyclopedia of Geochemistry* (C.P. Marshall and R.W. Fairbridge, eds., Kluwer Acad. Publ., 1999), and confirmed my impression (p. 316): he is regarded as the "Founder of Biogeochemistry." Creating the term "biosphere," he introduced a fundamental concept linking lithosphere-hydrosphere-atmosphere.

This biosphere, however, is not an exclusive domain of the biological community or the weird spirit world of James Lovelock's "Gaia Hypothesis." Vernadsky recognized clearly that the biosphere was an evolving medium, developing in complexity throughout the history of the planet Earth.

Planet Earth as an environment for evolving life should be seen in the context of several fundamental laws, not all of which appear to be widely appreciated in the biological community (see *Encyclopedia of Climatology,* Oliver and Fairbridge, eds., 1987). Law I is solar dependency; Law II is physical evolution; Law III is biological evolution (and so on). The crux of the matter is this: Evolution is a two-pronged advance, both for the biota and for the solid Earth, its ocean, air sediments, everything. . . .

Your correspondent Pascali speaks disparagingly of Darwinism, equating it somehow with Gaiaism. I'm not sure I understand what she means by "Darwinism," but I fancy it is some creation of the "New Age" humanists. That would be a pity because in the history of earth science, Charles Darwin was the greatest figure of the 19th Century. He liberated us from Lamarckism, Cuvierism, and the creationists. In geology he recognized the mobility of the Earth's crust and the eustatic potential of sea level and of ice-age winds. Biologists like to claim him as their own, but the Earth claims him too—a Man for All Seasons.

With the 20th Century came the new paradigm: first and foremost, Alfred Wegener's continental drift, widely rejected by the "Establishment" for 60 years or more, but eventually embraced into the general framework of plate tectonics. Incidentally, the movement of plates solves many questions in biogeography, just as Holocene climate oscillations explain the Southern Hemisphere distribution of penguins to South Africa, Australia, and South America, as accidental passengers on floating ice.

In the Earth Sciences again we have a 21st Century intellectual development in the field of biotic evolution. Already, in the last few decades, the space program has led to an appreciation of the role of asteroid (bolide) impacts on the landscape. For Darwin, biotic evolution was "little by little." In the 20th Century Stephen Jay Gould (one of my former students, by they way) gave us "punctuated evolution," and now Michael Rampino (also one of my former teaching assistants) gives us the "Shiva Hypothesis." This is almost a return to Lamarckism, but the "Hand of God" is replaced by astronomy and the occasional visitor from the outer ripples of our galaxy. The widespread biotic extinctions create an ecologic vacuum which invites rapid recolonization, but including all sorts of mutants some of which (thanks to Darwin) will survive and prosper. Evolution is more like a staircase of sharp risers alternating with broad plateaus.

Rhodes W. Fairbridge
Amagansett, N.Y.

Laurence Hecht Replies

Thank you for your comments on Vernadsky. We look forward to presenting some of your interesting work on solar determination of climate and weather to our readers soon.

On the matter of Charles Darwin, we disagree. This is best addressed from the deeper standpoint of scientific method

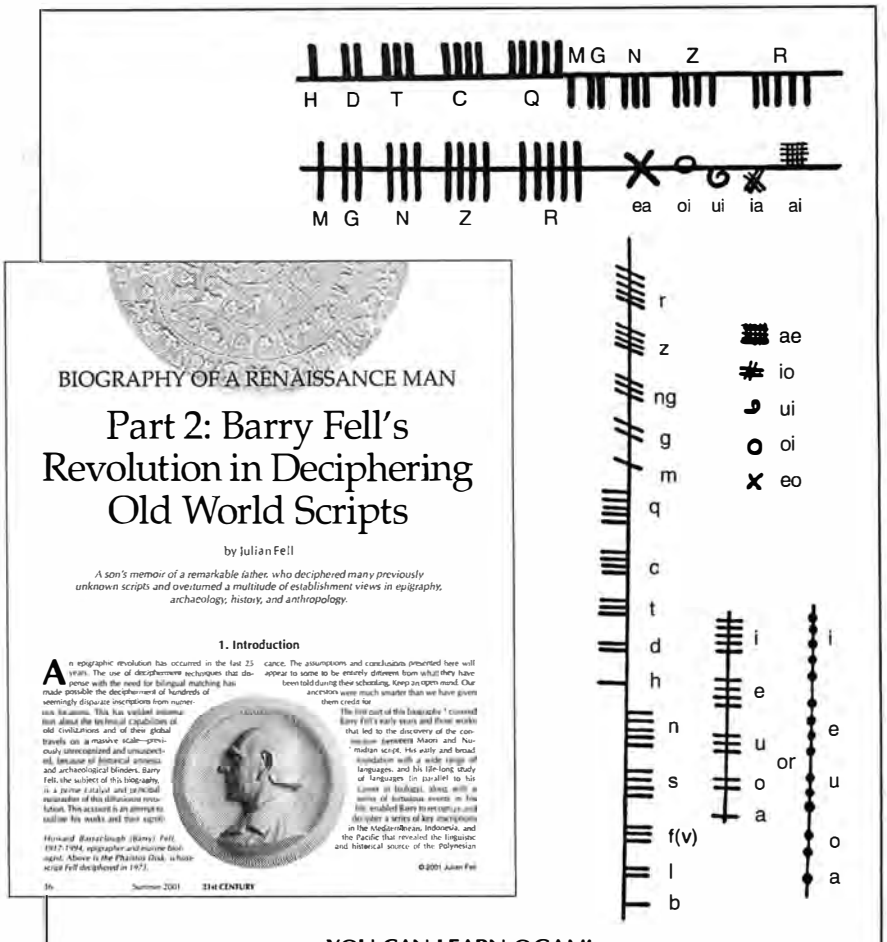
and philosophical outlook. The problem with Darwin's work, and nearly all of modern scientific commentary on same, is the tacit acceptance of the underlying premises of Locke and Hume's empiricism. Darwin (and more so his modern followers among molecular biologists) attempts to construct life from the bottom up, so to speak, beginning from the assumed existence of self-evident, elementary entities, known as atoms. "Evolution" is considered to be the aggregation, more or less by chance, of complexes of such inanimate elementarities into an accidental state called "life." Cognition and the higher processes of life, are merely more such accidents.

Among the problems of this view, is that, if one believes it, there is no reason to construct any such thing called science, which begins from the premise that it is possible to discover a lawful ordering principle in nature. To claim to have proved that all is accident, is to have disproved the possibility of science.

The competent opposition to Darwinism is not creationism. The opposing philosophical-methodological viewpoint is summarized by Gottfried Leibniz in his *Monadology,* a work which is little understood today. Among the points which a modern would usually find egregious:

- The most elementary entity is not a lifeless atom, but a monad, which is more akin to a soul.
- The principle of life exists in the universe from the "beginning."

We suggest the recent book by Lyndon H. LaRouche *The Economics of the Noosphere,* published by EIR News Service, P.O. Box 17390, Wash. DC 20041 ($20) for some further penetrating discussion of Vernadsky from the standpoint of the role and function of human cognitive activity in further development of the Earth. The first complete English translation of Vernadsky's "Problems of Biogeochemistry II" is included therein.



YOU CAN LEARN OGAM!

Ogam, mostly associated with the Gaelic Celts of the British Isles, has now been found to occur widely outside Britain. The letters consist of a series of strokes arranged along a stem line. They are grouped in numbers of one to five, and lie above, below, or across the stem line, which can be horizontal or vertical. Frequently, a crack, or a ridge or a corner on a stone is used as the stem line.

The post-Roman version in Britain includes vowels. The earlier and widespread version is vowel-less. S *and* Z, F *and* V, C *and* K, J *and* G *are mutual substitutions.*

Source: Julian Fell, "Barry Fell's Revolution in Deciphering Old World Scripts," *21st Century,* Summer 2001, p. 36

A Letter on Language To Author Julian Fell

Dear Dr. Fell:

I am a subscriber to *21st Century Science.* I knew little of philology or epigraphy until the articles began on your father. I was amazed and fascinated. . . . Your articles inspired me to learn to read and write the Dutch language. In addition, my children and I have learned to read and write Ogam, and have fun writing messages back and forth. I can't wait until your next article on Native American philology. I am descended from the Cherokees and Utes, and I am very interested in knowing where we came from.

There is an amateur philologist by the name of Edo Nyland who claims to have found a very strong link between Dravidian and the Basque languages. His postulates are unconventional, but I am not a philologist, and don't have the education to judge for myself. He does give word lists with a large number of hits between the two languages.

I would like to thank you for taking the time and diligence for writing such fine articles. They have made a wonderful impression on me.

Stephen Coleman, Jr.

Julian Fell Replies

Thank you for your kind and supportive remarks. It is pleasing to me to hear that they have inspired persons to take a look at learning foreign languages. I

Continued on page 7

METALINGUAL DECIPHERMENT

The Implications of Sumerian

by Lyndon H. LaRouche, Jr.

Today's (belated) encounter with Julian Fell's contribution to the Summer 2001 *21st Century,*[1] reminds me of my wrestling against the standard, pro-Biblical Archaeological, British treatment of Sumerian cuneiform, back during the early through middle 1950s. How should we read the Akkadian and later, Semitic rendering of the cuneiform, especially in light of the obvious functional continuity of the Sumerian cuneiform to the Sumerian culture, which was an offshoot of the Dravidian maritime culture's language-group?

I have some well-developed, strong feelings on this matter, an issue closely related to my perpetual horror at hearing what pass for baby boomers' attempts at academically literate mouthings of Classical poetry and drama. Reading from the written text itself, will tend to promote the worst outcome; reading from a remembered text in the memory, is usually little better, and sometimes even much worse. Julian Fell's appreciation of features of his father's pioneering work, points in a relevant direction.

"For sane people generally, as for Plato and Heraclitus before him, nothing exists but change."

The dead-mindedness of forms of grammatical speech consistent with the influence of Aristotle, is typical of the problem, as *The New York Times*'s style-book on spelling, punctuation, and prose composition, is an even more morally degenerate conception of prose and poetic composition than that of the brain-deadening Aristotle. The essence of the problem, the same problem posed implicitly by bilingual matching, is the attempt to reduce statements to a symbology-colored form of essentially deductive exposition. The problem parallels, and overlaps the fallacies associated with the delusion that the application of the methods of statistics to financial accounting, is the basis for economics.

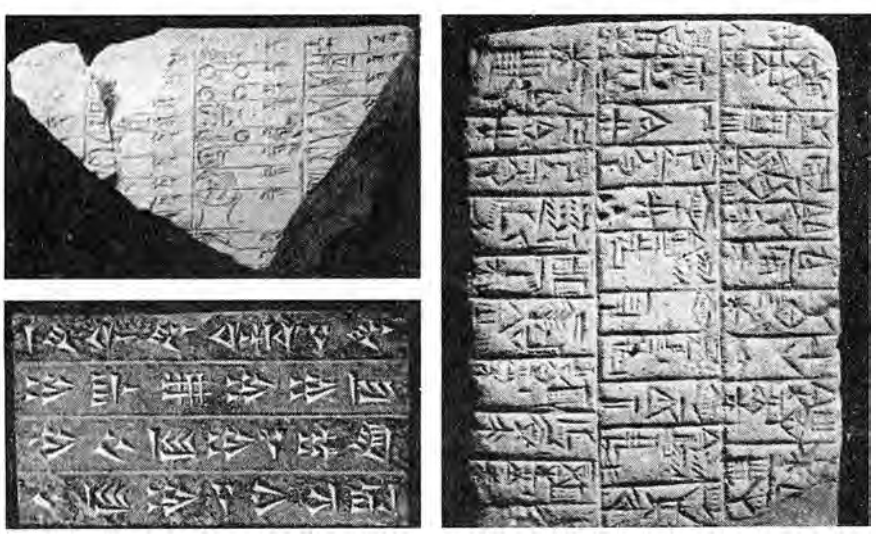
To summarize the core of the argument, the distinction between human behavior, and that of hide-bound deductionists, is that in cognitive communication the verbal action always transforms the subject-matter, in the same general sense that a chemical reaction does. The "is" of identity, of deduction, virtually does not exist functionally in a literate form of human communication. For example, in literate thought one never thinks "I am"; one thinks of what one has been made to become to be. Nations and peoples do not exist; they have come into existence. For sane people generally, as for Plato and Heraclitus before him, nothing exists but change. By "change," we should signify, essentially, the process of transformation linking two successive points of observation, or some kindred notion of change as the meaningful basis for acts of comparison.

In Classical poetry, this role of change is expressed most clearly by the functions of irony, especially metaphor. The essential mode of action which defines any such poem, is a metaphor situated amid ironies.

These nested ironies are usually brought into existence for the audience as a juxtaposition of different voices within a single statement, or a kindred juxtaposition of integral statements. In Classical poetry, this function of voicing is adapted from those natural potentials of the human singing voice which are brought out, and brought under control only through the Florentine bel canto mode of training the singing voice.

(For example, "instrumental music" does not exist, except perhaps among the racket which the feral nightly cats make among the cans and lids of the alleyway, or pianos performed to similar ultimate effects. All true music performed with man-made instruments, is a voice taught to sing in imitation of the qualities of the human singing voice.)

If a simply literal matching of languages can not contain the idea expressed by each, how might the



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Examples of Sumerian cuneiform. Decipherment has to take into consideration the functional continuity of the Sumerian cuneiform to the Sumerian culture, which was an offshoot of the Dravidian maritime culture's language-group.

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An impression clay seal from the Indus Valley, 3rd Century B.C. The Dravidian language culture of the Indus civilization colonized the Indian Ocean littoral, including Mesopotamia.

meaning of an unfamiliar language be adduced? Astrogation and related study of ancient astronomical calendars, point to a general principle for solving such problems. In each of latter cases, we have a real object, the universe. By aid of observations of that reality, man attempts to master some challenge.

For example, in cases of ancient navigation, the included subject-matter of any symbolic records left, is implicitly obvious. The trick, is to get inside the mind of the navigator and his party, and imagine that we are that person in that situation.

The general principle involved is typified by the case of a Riemannian differential geometry, as I have applied this to the material of a science of physical economy. We may recognize what is being said, from adducing the kind of reality which corresponds to the geometry of the relevant set of utterances.

That situation points to the importance of a certain sense about historical specificity.

So, for example, the case of Sumer, as emphasized by the account of the historian Herodotus. From him we are informed that the Phoenicians, ancient Sheba, ancient Abyssinia, and Sumer, were among the colonies founded by a maritime culture ostensibly dominating the relevant regions of the Indian Ocean during a period preceding the Aryan invasion of the Asian subcontinent. The sundry archaeological fragments show a relatively powerful such maritime culture of broadly Dravidian language-pedigree during that interval, a language which interacted with the Aryan's Vedic.

To situate these developments, including the Aryan descent upon South Asia, we must take into account the most catastrophic phases of the post-17th millennium (B.C.) glacial melt, and the succession of climate changes, especially from about 10,000 B.C. onward. In brief, we must situate the shards of evidence and their relationship to one another, within the physical geometry of the phases of ongoing transformation in the geometry of the relevant regions.

We must, in a certain sense, re-awaken in ourselves, a memory of the quality of passions which must have occurred in those ancient times.

Take the case of two plays of Schiller, his earlier *Don Carlos,* and his later *Wallenstein* trilogy. When we study closely the actual history of the events within which Schiller situates those dramas, as he does the case of Jeanne d'Arc, the passions which Schiller reawakens are revealed to us as the appropriate passions experience by the referenced events in real life as real life is to be situated in the historical specificity of those places, times, and conditions. Nor can we overlook the historical specificity of the distance and links between those historical events of the past, and the audience experiencing the dramatic examination of real history.

Both of the first two tragedies, reference the decadence of Europe under the tyranny of the Habsburg/Hapsburg dynasty: Spain fallen victim to Charles I and his successors, through the period of the evil of the 1511-1648 religious wars orchestrated by Venice on behalf of their Habsburg tool. It is as we situate the communications to be studied within the cognitive grasp of the historical specificity of the "geometry" of the situation, and the situation defined by the past's relevance for the present, that the actual meaning of the communication may be adduced, and in no different way.

In the diffusion of culture, the most significant events are not the translation of doctrines of one language into another, but the way in which the common cognitive element of the communication and related practice is expressed, similarly, or dissimilarly, in each. The problem is that modern academic and related miseducation and related prejudices, overlooks the act of hearing by the inner, cognitive ear of the mind, where the functional, cognitive meaning of the reality, behind the mere shadows called words, is to be found.

Economist and statesman Lyndon H. LaRouche, Jr. is on the Editorial Advisory Board of 21st Century *magazine. His communication is dated Nov. 16, 2001.*

Notes

1. Julian Fell, "Biography of a Renaissance Man, Part 2: Barry Fell's Revolution in Deciphering Old World Scripts," *21st Century,* Summer 2001, pp. 36-63.

Letters to the Editor

Continued from page 5

have always felt that North American education has neglected this view. I am always embarrassed in the presence of foreigners who speak multiple languages with such ease. This is in large part due to the absence of opportunity in North America, but also regretfully due to a kind of willful ignorance. After learning the fundamental basis of the Indo-European languages, I now find it very easy to pick up a book about almost any language of this group, and catch onto the basics of the vocabulary and grammar almost right away. If my writings enable others to do this, then it gives a sense of having done something useful. Thank you for that.

I have heard that speakers of Basque, Georgian, and Shoshoni recognize similar words in each other's languages; and you appear to have a source that Tamil, which is a Dravidian language (very ancient, from southern India) may be connected also. I am no authority, so I cannot comment further, just make a note of it.

Communicating by Ogam is a neat little trick, as it can be acquired so easily by children. It also lends itself to being communicated by hand signs (just holding up, or down, the right amount of fingers). Hand signage is believed to have been the origin of Ogam, each finger combination representing a letter. It is also puzzling, because in order to exploit it this way, one would have to know the language, and be close enough to be seen—in which case, why not just walk up and speak directly? Something to speculate upon.

NASA

U.S. budget cuts threaten the completion of the International Space Station and its scientific research capabilities. Here, astronauts Sturckow, Barry, and Forrester in orbit.

PROTESTS MOUNT OVER U.S. CUTS TO INTERNATIONAL SPACE STATION

The Bush Administration's proposal to eliminate the U.S. contributions to the International Space Station, which would make it impossible to complete the project as designed, has angered America's international partners, and many in the U.S. Congress. Europe, Japan, Russia, and Canada have already spent billions of dollars to design and produce their hardware for the station, and have trained their astronauts, in the expectation that they will be able to share in the scientific research resources of the station, as stated in international agreements. And Congress faces the bleak prospect of having spent tens of billions to orbit the station, only to have it lack the capability to carry out the science research, which is its purpose.

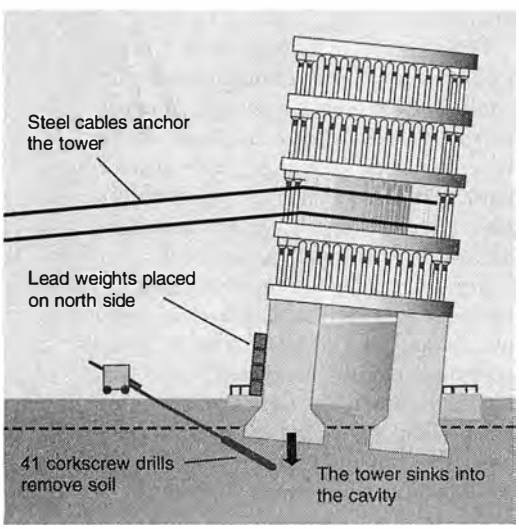
President Bush has apparently delegated responsibility for the space program not to his science advisor, or to NASA, but to the Office of Management and Budget (OMB). Sean O'Keefe, the nominee for NASA Administrator, comes to the space agency from the OMB, and has stated in the past that the administration will accept no increases in NASA's budget to cover cost overruns in the space station, that the project will have to be "downsized."

ENRICO FERMI HONORED AT ITALIAN EMBASSY IN WASHINGTON, D.C.

U.S. Secretary of Energy Spencer Abraham, and the Ambassador to the U.S. from Italy, H.E. Ferdinando Salleo, jointly sponsored a "Celebration Honoring the Centennial Birthday of Enrico Fermi," Nov. 27, at the Italian Embassy in Washington, D.C. Italian nuclear physicist Fermi led the effort to build the first nuclear fission pile in 1942, at the University of Chicago. This great turning point in the first realization of nuclear energy in the 20th Century was marked by the coded message: "the Italian navigator has landed in the New World."

The celebration included a seminar titled "The Legacy of Enrico Fermi in America: Science, Energy, and International Collaboration," addressed by U.S. Deputy Secretary of Energy Francis S. Blake and Presidential Science Advisor Dr. John Marburger. The high point of the seminar was the presentation by Dr. Harold Agnew, the former director of Los Alamos Scientific Laboratory, who was a student and close collaborator of Fermi. Agnew went from the University of Chicago, where Fermi built the first nuclear pile, to Los Alamos during the war. He showed a film of Fermi mowing his front lawn when Agnew was only a graduate student: "Not many grad students have their Nobel Laureate Professor mow their lawns for them," Agnew quipped.

To the audience's surprise, Dr. Agnew pointed out that Fermi's favorite was Dr. Edward Teller, despite their apparent differences in style, politics, and general philosophy. Agnew also noted in passing that maybe Fermi was the first to suggest to Teller that he look into "radiation-driven compression" to achieve nuclear fusion—the key to harnessing the hydrogen bomb which Teller had been working on.



New Federalist, Dec. 24, 2001, p. 11

The engineering approach involved cables and lead weights to secure the tower while the soil was removed, in order to stabilize the tower in the cavity.

LEANING TOWER OF PISA REOPENS AFTER ENGINEERS STABILIZE ITS TILT

One of Italy's most famous landmarks, the 190-foot "Leaning Tower of Pisa," reopened to the public in December, after a 12-year restoration project by an international team of scientists and engineers. Construction on the tower began in 1173, and because it was unknowingly built on the soft silt of a buried riverbed, it began to list almost immediately. By 1990, the tilt of the tower had become so pronounced (nearly 17 feet), that it was feared it would fall over. The stabilization plan was the brainchild of John Burland, professor of soil mechanics at Imperial College, London. Based on his calculations, engineers extracted soil from beneath the Tower's foundations, in what was described as "the civil engineering equivalent of microsurgery." Highly sensitive detectors measured the slightest movement of the tower at each stage of the intervention.

GRAHAME WALSH WINS SUIT AGAINST OXFORD ON ROCK ART SLUR

Australian rock art expert Grahame Walsh, whose work was featured in the Fall 1999 *21st Century,* won a lawsuit in October against Oxford University Press and the Australian National University, for defaming him in *The Oxford Companion,* published in 2000.

An article written by an archaeologist, titled "The Dating of Rock Art," stated that Walsh's work on the Bradshaw paintings in the Kimberleys "are too fine to be Aboriginal and must be the work of earlier peoples some 75,000 years or more ago, have no archaeological basis, and are informed by racist perceptions of what Aboriginal people are capable of." Walsh has never claimed that the Bradshaw art (see illustration) is 75,000 years old, but probably 25,000 years old, and he never made a racial slur.

As a result of the suit, Oxford University Press had to recall thousands of copies of *The Oxford Companion,* in order to insert a revised article, while the Australian National University has to pay Walsh's legal costs and print an apology in three Australian archaeology journals.

The reason for the hysteria about Walsh's work is that it proves that the Aborigines were not "the first Australians," and therefore threatens to overturn the land rights scam, promoted by Prince Philip and his Worldwide Fund for Nature, which has sequestered large land areas and their mineral resources in the name of Aboriginal rights, away from the use of the state and into the hands of private multinational interests.

Courtesy of *The New Citizen*

One of the Bradshaw rock paintings discovered and recorded by Walsh over the past 25 years, in his data base of 1.2 million images of rock art. The paintings are named after explorer Joseph Bradshaw, who first observed them in 1895.

RITALIN HAS SAME EFFECTS AS AMPHETAMINES AND COCAINE

Ritalin, commonly prescribed for children with so-called Attention Deficit Hyperactivity Disorder, has effects similar to those of methamphetamines (speed) and cocaine, according to new research. A research team at the University of Buffalo has found that Ritalin "has potential for causing long-lasting changes in brain cell structure and function," and that "genes linked to [Ritalin] addiction" are the same as those affected by cocaine and amphetamine." The findings were reported Nov. 11 by Reuters.

CHINA REAFFIRMS PLAN FOR FIRST MANNED SPACE FLIGHT

Speaking at a forum in Beijing Nov. 22, Luan Enjie, administrator of the China National Space Administration, reiterated his nation's plan to orbit its first astronauts by 2005. Attending the forum were more than 100 leaders of the Chinese government, including the ministries of Development and Planning, Foreign Affairs, the Academy of Science, and other aerospace research institutes. Luan emphasized that no astronauts will fly until their safety can be assured.

At an earlier forum, Academy of Sciences member Jiang Jingshan delivered a report describing the exploitation and utilization of energy and mineral resources on the Moon. Jiang proposes sending orbiters, then rovers and sample return missions, and eventually human explorers. The ultimate goal, he said, is setting up a "lunar village."

FRANCE SETS UP MAD COW DISEASE LAB AT ATOMIC RESEARCH CENTER

A new Biosafety Level 3 microbiological laboratory, devoted to research into Bovine Spongiform Encephalopathy (BSE or mad cow disease) was inaugurated at the National Atomic Research Center in Saclay, southwest of Paris, Oct. 11. The facility will study the modes of inter- or intra-species transmission, and work to develop diagnostic and therapeutic techniques. The first stage of research will be the immediate application of a screening test for BSE, already developed for nerve tissue, to other related tissues.

Médias Com France

The initial phase of the laboratory has already been built, including a test room, an animal house, and a cell culture lab for the production of monoclonal antibodies. Here, a biosafety researcher.

John M. Dawson, Fusion Torch Pioneer, Dies

by Charles B. Stevens

One of the giants of plasma physics and fusion energy research, John M. Dawson died on Nov. 17, 2001, at his home in Los Angeles. He was 71. Dr. Dawson was a professor of physics at the University of California at Los Angeles (UCLA) and the director of its center for plasma physics and fusion engineering. He also worked at TRW on various government projects.

Professor Dawson experimentally pioneered the concept of the soliton while working at Princeton Plasma Physics Laboratory. He later developed the concept of a "plasma particle accelerator," which can generate huge electric fields to accelerate subatomic particles to near the speed of light in a few millimeters, instead of tens of miles.

John Dawson's major achievement was the realization of the first industrial-scale and effective "fusion torch," while working at TRW in the mid-1970s. In 1975, an Egyptian physicist working at the University of Iowa determined that all previous calculations concerning the fusion torch were incorrect, and that the fusion torch was a practical technology that could be immediately available, even before fusion reactors were realized. As a result of her finding, TRW and Lawrence Livermore National Laboratory launched a crash program to realize the fusion torch, which they called the Plasma Separation Process (PSP). Dawson headed up the experimental team.

A Beautiful Idea

The fusion torch is a beautiful idea. Because a fusion plasma operates at 100 million degrees, all materials introduced into it are instantly ionized. That is, all chemical bonds are immediately broken. This means that any chemically hazardous material can be readily and safely destroyed, such as biochemical weapons.

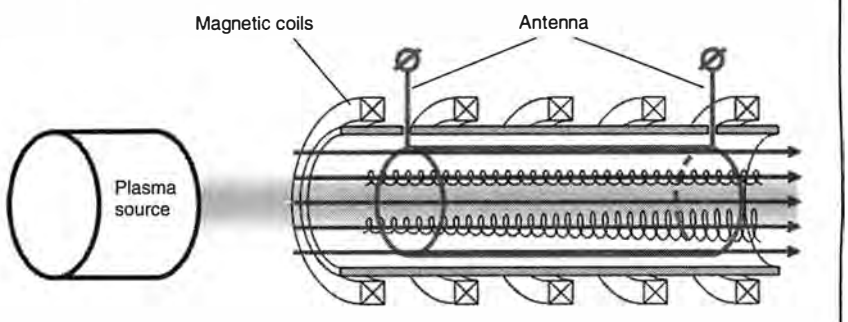
But that is only the beginning. Because the fusion plasma is contained by a magnetic field, the various chemical elements and *chemical isotopes* can be readily separated. This means that trash and hazardous materials are put in at one end of the torch, and valuable materials come out at the other end—the ultimate recycling machine.

John Myrick Dawson (1930-2001)

This procedure also holds true for nuclear waste. Instead of dangerous radioactive materials, the Plasma Separation Process would transform the waste into valuable non-radioactive transition metals and radioisotopes for medical applications. The economical separation of all chemical isotopes would also make possible the construction of long-lived and safe nuclear power plants. The so-called waste problem would be eliminated.

Despite the enormous potential of plasma separation, President Jimmy Carter was opposed to the development of nuclear energy, and so he had the Plasma Separation Process program killed, and the technology buried under secrecy.

John Myrick Dawson was born in Champaign, Illinois in 1930. He received his bachelor's degree and Ph.D. from the University of Maryland (where the author first met him as a child) in the mid-1950s. He worked at Princeton and then at UCLA. There would be no more fitting memorial for Prof. Dawson than for the United States to revive the fusion torch, and reinstitute the program to develop his Plasma Separation Process.



The Plasma Separation Process, the first working fusion torch, perfected by John Dawson during the mid-1970s, when he was at TRW.

A source of mixed isotopes is introduced as a plasma, at left, into the magnetically contained chamber. Radio antennas tune in to the desired isotopes, increasing the radii of their spiral paths. Using a barrier which is shaped like a venetian blind, the tight spiralling isotopes pass through, while the larger radius isotopes are trapped in the plasma chamber. In this way, isotopes of any desired kind can be efficiently and easily separated in one stage.

Pedro Paulet: Peruvian Space and Rocket Pioneer

by Sara Madueño Paulet de Vásquez

The inventor of the liquid fuel motor (1895) and the first modern rocket propulsion system (1900) was a Peruvian engineer and statesman. His story is told here by his great niece.

Taking on the economic, moral and cultural crisis that is ravaging the world today, requires a new universal cultural renaissance, in which each nation adopts a national educational policy designed to encourage our children and youth to rediscover and take as their own, the classical principles which have occupied the best scientific, artistic, and philosophic minds of our civilization.

In this context, it becomes necessary to bring to the fore those great men and women who represent a point of reference, a touchstone for evoking a commitment to the sciences, to discovery, to good government. Among this exemplary lineage of world citizens, is the great Peruvian scientist Pedro Paulet (1874-1945), pioneer of aerospace aviation, who also postulated the principle of universal scientific and classical education, as the basis for progress among peoples.

Pedro Paulet discovered the advantages of liquid fuel for rocket propulsion, and designed, built, and tested the first liquid fuel rocket engine known to history. Paulet also designed an early spaceship prototype.

Peru also counts among its illustrious sons, the astronaut Carlos Noriega who, as a member of the December 2000 Endeavour Space Shuttle crew, helped install the solar panels of the International Space Station (ISS). The ISS represents the bridge across which man must travel on his way to the colonization of the Moon, then Mars, and beyond.

Paulet and Noriega, seen from this historic viewpoint, represent a continuity of the same purpose: to extend the boundaries of man into space, to be fruitful and multiply, as *Genesis*

This bust of Pedro Paulet graces the exhibit of his sketches and models at the Pedro Paulet room of the Aeronautical Museum of the Peruvian Air Force in Lima, Peru.

commands. They also represent positive role models for guiding our children and youth along the road of science and discovery, to the benefit of all humanity.

In his book *World History of Aeronautics* (co-authored with Fred Ordway), Wernher von Braun, former head of NASA's Marshall Space Flight Center, and director of the Saturn V rocket that took men to the Moon, states: "Pedro Paulet was in Paris in those years (1900), experimenting with his tiny two-and-a-half kilogram motor, and achieved 100 kg of force. By this act, Paulet should be considered the pioneer of the liquid fuel propulsion motor." Further, in his *History of Rocketry and Space Travel,* von Braun recognizes that "by his efforts, Paulet helped man reach the Moon."

Paulet's scientific contributions were not, however, limited to the discovery of the advantages of liquid fuel for rocket propulsion, or the design of the reaction motor known as the "Paulet Motor" (1895), and the design of the Girándula propulsion system (1900). He also designed the "Avion Torpedo" (1902)— his "perfect airplane," which is an aerospace ship with specific aerodynamic characteristics, and room for a small crew, resistant materials for space and atmospheric conditions, thermal walls, and electricity supplied through thermoelectric batteries.

As a child, Pedro Paulet was fascinated with the idea of using rockets to reach into space. He went on to carry out the first experiments with liquid fuel rocket engines.

In the National Air & Space Museum in Washington, D.C., we can see a small plaque honoring the memory of the Peruvian Pedro Paulet, as one of the fathers of aeronautics. But Paulet deserves more than a plaque in his honor. He is a model for the present and future generations of the world, but especially for the so-called "Third World." He was one of many children born into a mestizo family living in one of the thousands of forgotten little villages in the Peruvian jungle, who demonstrated through his contribution to universal science that every person is capable of achieving the highest level of human creativity.

In Peru, Paulet is not only considered the "greatest Peruvian inventor of all time," but his birthday, July 2, has been officially declared National Aeronautics Day.

The Peruvian Air Force, in its Aeronautics Museum in Lima, has made the "Pedro Paulet Hall" into a major exhibit, where Paulet's works, original sketches, and scale models of his inventions, are on view.

'Reaching Space,' a Childhood Dream

Pedro Paulet Mostajo (1874-1945) was born on July 2, 1874, the son of Pedro Paulet and Antonia Mostajo, in the small town of Tiabaya, near the prosperous city of Arequipa in Peru's southwest. According to Megan Paulet, his daughter:

> From early childhood, Pedro Paulet showed a passion for reaching the stars. With his primitive model rockets, inspired by the town's fireworks, his whole childhood was a collection of anecdotes about his curiosity for discovery and scientific creation; curiosity that often led him into risky experiments.

After a strict primary and secondary education under French Lazarists led by Father Duhamel, Paulet entered the St. Augustine University of Arequipa, where he studied arts and sciences for several years. In 1894, when he was 18, the Peruvian government gave Paulet a scholarship to study engineering and architecture at the Sorbonne in Paris, in recognition of his academic excellence. He later enrolled also in the School of Fine and Decorative Arts. While studying engineering and architecture, Paulet attended public lectures in chemistry by Prof. Marcelin Berthelot at the College of France, in Paris. Then, in 1898, he decided to enroll at the Applied Chemistry Institute at the University of Paris to study with Prof. Berthelot.

In an interview with Argentina's *La Cronica,* on April 18, 1944, Paulet recalled that, "at the Institute I was mainly attracted to the work of Berthelot, on the forces of explosive materials. I could not understand why his book is not featured in every technical library."

Paulet graduated from the Institute in 1901.

From the very beginning, Paulet concentrated on research and experimentation in that area which had obsessed him since childhood: rocket design and propulsion. For Paulet, the dream of plowing through space depended solely on the infinite capacity of individual human creativity. Convinced that there are truly "no limits to growth," and that man's mission is to go forth and multiply, and dominate the Earth, he stated, in an interview with *La Crónica* in 1944:

> Progress does not consist of matching the processes of nature, but of surpassing them. [Thus] what we must study is not aviation as it comes from the birds, and which only invites us to imitate flight, but weightlessness. Transport above the planet must be probed, where there is no air, no clouds, no ice.

At the same time, Paulet conceived and designed his "flying machine to reach space," and he began a period of intense experimentation. His challenge was to find the most appropriate explosive to use as a propellant. This issue dominated his constant consultations with his teachers: Charles Friedel (renowned chemist and mineralogist); Marcelin Berthelot (known for his work in organic chemistry and thermodynamics); and the famous Pierre Curie (Nobel physicist in 1903, who together with his wife Marie Sklodowska Curie and Henri Becquerel, are considered the pioneers of nuclear energy by virtue of having discovered polonium and radium).

It was during this stage of his life (1895-1902), that Paulet reached the first conclusions that would lead him to the discovery of liquid rocket fuel, and later to the physical principles upon which he based the conception and design of the Paulet Engine, the Girándula device, and, finally, his Torpedo Plane.

The Experimental 'Paulet Engine' (1895)

In Paris, Paulet dedicated himself to his project. When both the conception and form of his "flying machine" became clear, he designed both (see Figure 1 and photograph of model).

British author A.V. Cleaver writes that, by 1900, Paulet

> has to his scientific credit, recognition of his invention of the "rocket engine," the first example of the bi-propellant rocket, where the oxidant and the hydrocarbon are in separate tanks, and only mix in the combustion chamber. This is a forerunner of that which is used in today's spacecraft, with the difference that today, nitric acid replaces the nitrogen peroxide used by Paulet.

In 1927, in a letter written in Rome on August 25, and published in October of that year in the Lima daily *El Comercio,* Paulet describes his prototype for the experimental reaction motor for rocket propulsion:

> My most definitive experiments were carried out with steel and vanadium rockets, then a novelty, and with Plankacite [a powerful explosive], which had just been invented by Turpin, the discoverer of melinite. The interior part of this metal rocket was a conical interior measuring some 10 centimeters high by 10 centimeters at the open base. Opposing ducts provided with spring valves, introduce nitrogen peroxide steam on the one side, and petroleum benzene on the other. Ignition was effected by an electric spark plug similar to that in an automobile, and placed halfway up the interior of the rocket.
>
> At the same time, to carry out the preliminary experiments, the rocket was ringed on the outside with long flexible tubes which connect the above-mentioned nitrogen peroxide and benzene tanks to a lead from the spark plug to the electric mains. The rocket would ascend between the two taut, parallel and vertical wires, between whose upper part was installed a strong spring thrust measuring device, supporting the pressure of the firing rocket. The dynamometer could give the approximate measure of the lifting forces.
>
> The results of these experiments were very satisfying. A single two-and-a-half kilogram rocket, undergoing 300 explosions per minute, could not only maintain a constant pressure against the dynamometer, of up to 90 kilograms, but could operate without damage for nearly an hour. Under such conditions, it would not be reckless to predict that, using two batteries of 1,000 rockets apiece, one in operation while the other rested, it would have been possible to lift several tons.

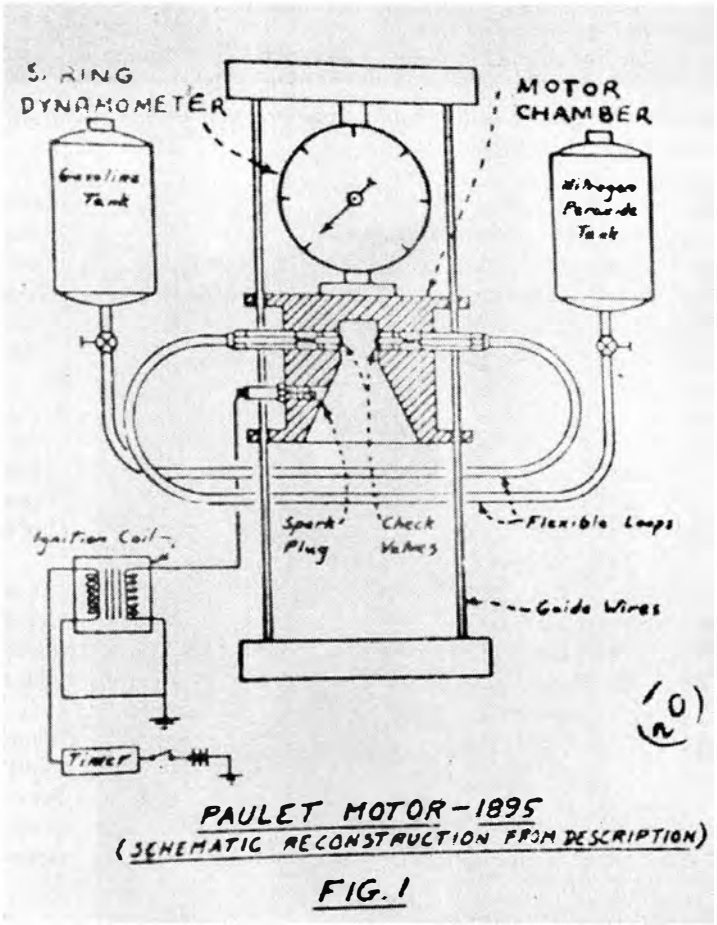
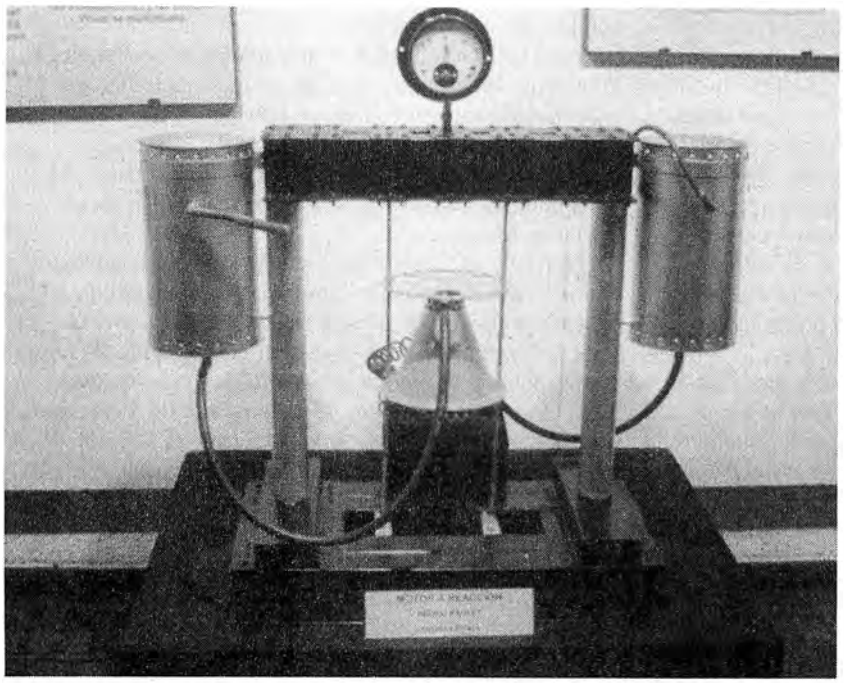
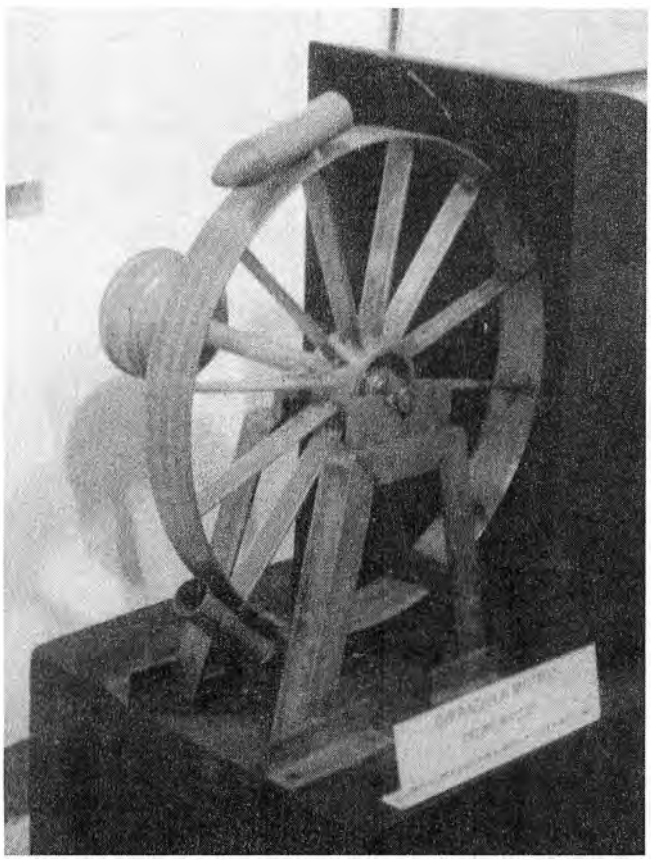


Figure 1
SCHEMATIC RECONSTRUCTION OF THE PAULET MOTOR
This diagram of Pedro Paulet's first experimental rocket engine was reconstructed by James E. Wyld in 1946, from the inventor's written description. The spring dynamometer at center top would measure the force produced by the thrust of the rocket engine below.



This full-scale model of the Paulet Engine is part of the exhibit at the Aeronautical Museum in Lima.



Pedro Paulet's Girándula *consisted of rockets attached to the outside of a wheel, to be fed fuel through tubes in the spokes. Ignition was provided by spark plugs, similar to those used in automobiles. The rocket exhaust caused the wheel to rotate.*

As can be seen in the schematic reconstruction of his "Paulet Engine—1895," rendered from his description (Figure 1), this is a detailed plan for the experimental reaction engine that Paulet invented. In fact, as he himself said, it was a conception for a rocket-airplane motor, or the "Torpedo Plane," as he was to call it.

'Girándula': Paulet's Liquid Fuel Rocket

Paulet undertook to study and experiment with rocket propulsion, using various kinds of explosives. Through extensive research and arduous experimentation, as well as the guidance of Professor Berthelot, he reached the conclusion that liquid fuel is most appropriate for the reaction motor. He also experimented with his rocket-propelled device, the "Girándula," which he describes in his 1927 letter to *El Comercio*, and refers us to the results of his experiments with this:

> It consisted of a bicycle wheel, fitted with three rockets fed by tubes attached to the spokes. The fuel comes through the tubes from a kind of fixed carburetor, placed near the axis, with a ring of holes. This explosive mixture flows through the tubes, every time the nozzle faces one of the holes. The number of rockets could be increased, until they come to look like a comfortably enclosed turbine.
>
> The results [of the Girándula tests] were very encouraging: the wheel turned apparently indefinitely, and although the experiments were, as indicated, highly secret, word of their success reached the Latin Quarter [in Paris], which is perhaps why an English author has referred to me as one of the first driving forces of rocket flight.

It was decided to use Turpin Plankacite, a powerful explosive derived from picric acid, for the liquid fuel. This was a highly volatile and expandable fuel, which could be diluted with the appropriate solvents. The experiments were a success. What now needed to be established was the speed of rotation that the rocket-powered wheel could reach. In the midst of his experiments, an explosion occurred, causing the perforation of Paulet's left eardrum, which was later to lead to deafness. In his 1944 interview with *La Crónica,* Paulet describes the accident as follows:

> A serious accident caused by an acetone explosion in a beaker next to a Bunsen burner, alarmed the Institute's director, Dr. C. Charbie, who vehemently prohibited the handling of explosives at the laboratories, which were then located in modest facilities near the Luxembourg Gardens in Paris. As I was unable to continue these experiments at my hotel—less so, when the police, on account of some anarchist activity, were unfavorable to the manufacture of explosives—I abandoned my work

on the Girándula motor, and its subsequent applications.

The Paris police detained Paulet, who was released when Professor Bethelot testified that he was not an anarchist. The police said that such experiments could only be done in military centers, or laboratories, not independently. Nonetheless, the efficiency of his experimental machine had already been proven.

The Paulet 'Torpedo Plane' (1902)

Paulet laid out the general concepts for a rocket plane's flight through the atmosphere, on its way to reach space, in his interview with *La Crónica*:

> It is not a matter of "attracting" the air, but of "pushing" the air with rockets. The ship with which we will reach space will have to be aerodynamic in form. . . . The propeller and the glider elements should disappear. They must be replaced with a new form, which corresponds to its astrodynamic functions, once gravity has been overcome through the rockets.

In the process of conceptualizing the design of his "flying machine," Paulet concluded that, "It is possible to traverse the atmosphere, both dense and thin, by means of ships whose ends must be like spearheads. . . ."

The interior of the flying machine, he said, should be such that:

> it must allow that, within the airtight chamber, the astronaut has full freedom of movement. To achieve this, the spherical form is certainly appropriate, because it is more resistant to external pressures.

The exterior of the machine, he said, should have a shape that:

> allows the outside tip to be maneuvered from inside the chamber. It must also be assured, as occurred with submersibles, that whoever inhabits it would have no problem controlling the interactions of the metal ship with the outside environment.

To achieve the "perfect airplane," that is, his spaceship, said Paulet, it must:

(1) ascend vertically

(2) stop [or hover] at any point in the atmosphere

(3) be able to fly at more than 20,000 meters altitude

(4) possess an exterior impervious to the atmosphere, and an interior comfortable enough for a large number of passengers and a great deal of cargo weight; and

(5) descend vertically.

"Torpedo Plane, Paulet System, 1902." That is how Paulet signed the final sketches of his spaceship, which he liked to call, in Spanish, "Autobólido." (See Figures 2 and 3). These final sketches can be found in Antwerp, a city in which he lived for several years, when he was named Peruvian Consul to Belgium in 1902.

Paulet describes his space ship in his 1927 article in *El Comercio:*

> The first advantage of the application of rocket motors is that they create a force external to the apparatus, but are controllable from within, thus allowing us to give that apparatus the most appropriate shape. In order to slide through a fluid, such as the atmosphere, which is a homogeneous and stress-filled mixture, the shape, in my judgment, should be that of a very convex lens, almost ovoidal like our planet. By incorporating batteries of rockets, positioned both below and equatorially, whose angle of firing could be varied, it would be possible to direct the vehicle vertically, horizontally, or obliquely, resisting any contrary forces that the atmosphere might produce, to remain in space, and then descend to the ground.

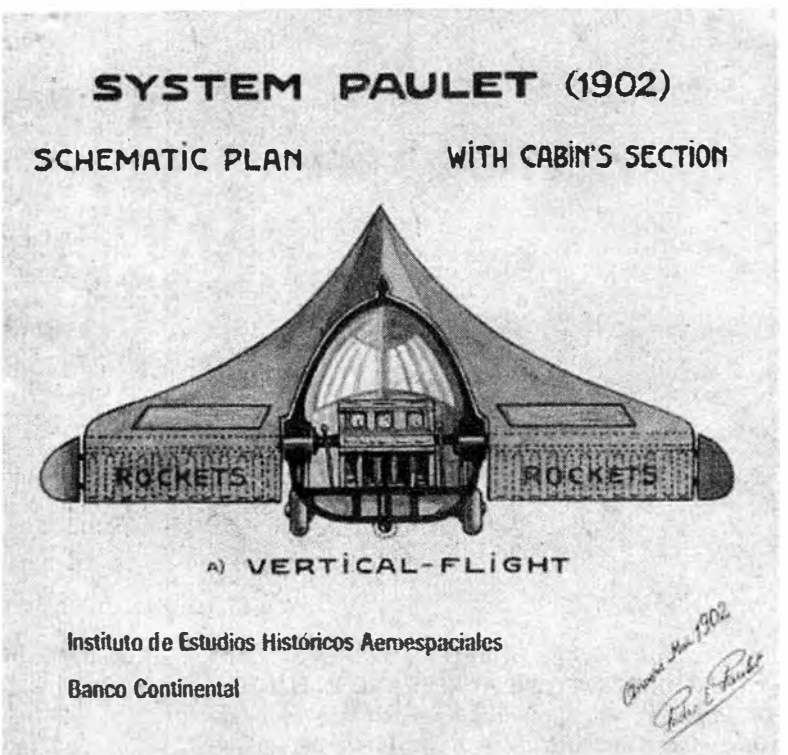


Figure 2
PEDRO PAULET'S ROCKET PLANE DURING VERTICAL FLIGHT
This front-view 1902 drawing by Paulet of his Torpedo Plane, shows the two batteries of rockets, on either side of the crew cabin. When the rocket plane is taking off, and is in vertical flight, the rockets, attached to the spear-shaped frame, are pointed downward.

Since this vehicle is destined to navigate stellar space, where there is no air, it needs neither propeller nor gliders. It is shaped like a triangular spearhead, on the base of which is placed, on each side of the astronaut's cabin, 12 batteries of 3 rockets per battery (that is, 36 rockets). This allows the orientation of this triangular spearhead to an axis on the center of gravity of the astronauts' cabin.

With such a system, a ship should be able to:

(a) Rise up vertically, with the spearhead pointed to the zenith;

(b) Maintain itself at any point in the atmosphere, using rockets to balance the force of gravity;

(c) Fly horizontally, with the spearhead rotated to point toward the horizon;

(d) Transition from the air to submersion in water, by aiming the spearhead below the horizon;

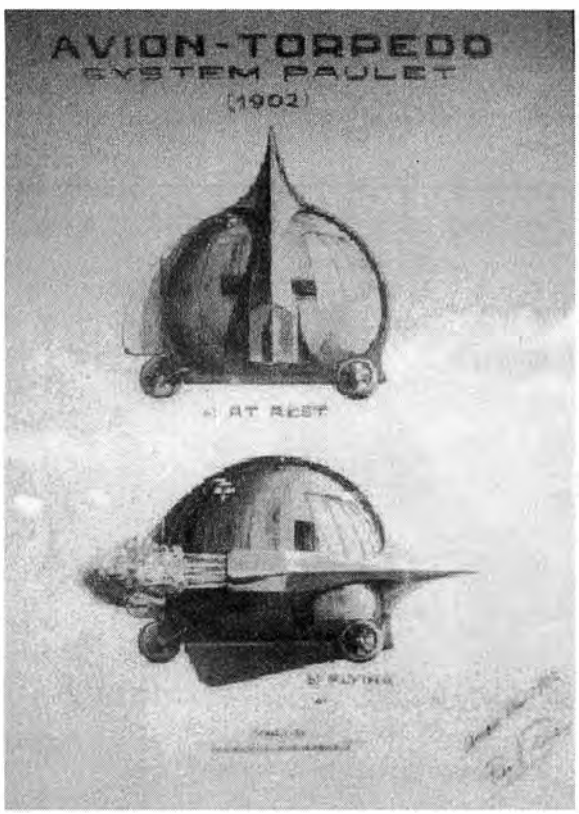


Figure 3
THE TORPEDO PLANE AT REST AND IN FLIGHT
The upper drawing shows the Torpedo Plane from a side view, while it is "at rest," or hovering in the atmosphere. The lower drawing, also a side view, shows the vehicle flying horizontally through the air. The spear-shaped triangle holding the rockets has been rotated a quarter turn, by the crew inside the cabin, from a vertical to horizontal postion. The spearhead is now pointed toward the horizon, in order to move forward, rather than toward the zenith, to ascend.

(e) Navigate under water, as a submarine.

In the 1927 *El Comercio* letter, Paulet made observations of the then "modern" airplanes, which he described as simple "self-propelled comets," with their "poorly performing propellers, their almost totally exposed bodies, and the impossibility of their remaining motionless in space. [They] satisfy none of the conditions" of the "perfect airplane." Paulet therefore suggests that "they should be viewed in aerial navigation as forerunners, similar to those sailing vessels in maritime navigation, which had also crossed the oceans."

Remember that while Paulet was presenting his daring "Torpedo Plane" in 1902, the American brothers Wilbur and Orville Wright, were completing their record of 1,000 glider flights.

Regarding the helicopters of that era, these, he says, while they "can rise and descend vertically . . . the complexity of their makeup has meant that thus far, they have been unable to carry out effective flights."

Many years earlier, in 1909, while working as director of the magazine *Ilustración Peruana,* Paulet had explained, in his article "War and Aerial Navigation," the advantages and disadvantages, as weapons of war, of the hot air balloon, kite, and dirigible, as well as the Wright biplane, the Bleriot monoplane, the Krupp cannon, and the self-propelled mortar.

Paulet wrote his 1927 letter to *El Comercio,* 25 years after his crucial discoveries and designs had already been made. Thus, he asks himself:

> With such advantages, one can ask why rocket-planes have not already been built, even more, why rockets have not been placed tangentially on a wheel, which would form the simplest and most powerful of industrial forces; and the why rocket projectiles have not eliminated the costly use of cannons in war, and so on. Well, as a result of my own experience, I can reveal why: It is because of the great difficulty that a civilian encounters, especially in Europe, trying to obtain information on, and experiment with, explosives. Moreover, the needed explosives, which are of the binary type and are not solid, but rather liquid or gaseous, are not sold commercially, due to their unsafe and dangerous composition.

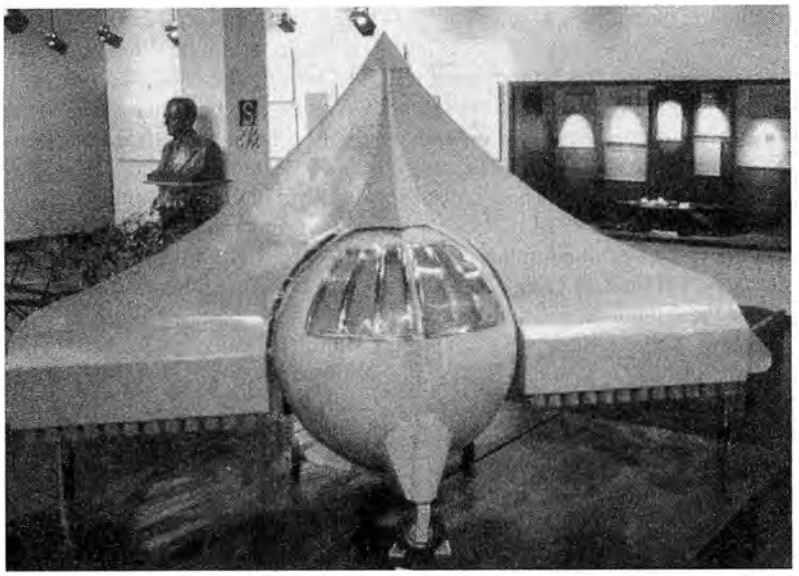
Anticipating Nuclear-Propelled Rockets

How is it possible, Paulet stresses in that letter, that the rocket-plane has not yet been built when, as he writes, it is already conceptually feasible in that period to imagine nuclear-propelled rockets?

> But during the past 15 years, the science of explosives is one of those which has made the most progress. . . . Internal combustion motors are replacing steam motors everywhere; pyrotechnics is no longer simply an art; and chemical manufacturers provide a range of explosives as varied as dyes and perfumes. And this progress is going to be even greater with the studies of radioactive forces. For example, M. Esnaut [sic] Pelterie has calculated that a rocket ship weighing 1,000 kilograms, with a motor

fueled by the disintegration products of a mere two decigrams of radium, would produce a force of 40,000 horsepower over a period of half an hour, sufficient to be able to go the Moon in 24 minutes 9 seconds, and return from that satellite in 3 minutes 46 seconds.

The truth is that we still don't know how to use the mechanical energy of radium, as we do that of petroleum. But, not much is needed to be able to travel modestly from Europe to Lima in a couple of hours.



This model of Paulet's Torpedo Plane clearly shows the rocket batteries underneath the spear-shaped triangle, and the ovoidal crew cabin, with windows. The bust of Pedro Paulet can be seen at the top left of the photograph.

Paulet, Pioneer of Peruvian Technical Education

In 1900, Paulet's life took a turn. Because of the various diplomatic responsibilities he was given by the Peruvian government, he joined the diplomatic corps. He was first assigned as Peruvian consul in Paris, and in 1902 he was transferred to Belgium, as consul general in Antwerp. It was there that he finished his drafts for the "Torpedo-Plane, Paulet system."

The Peruvian government assigned him a number of official duties, which distracted him from his project. But the government also needed his technical and scientific input for other projects. For example, they asked him to evaluate the feasibility of applying wireless telegraphy across the Pacific Ocean, and it is on the basis of his research that a telegraph system was installed in Peru.

In 1904, Paulet was called upon by the Peruvian government to assume the founding and directorship of the School of Arts and Trades (predecessor of the current Superior Technology Institute). To carry out this project, Paulet studied the curriculum of the most prominent centers of European technical education. He invited a prominent teaching team of engineers to join him in founding the School, which was also provided with the best laboratory equipment and machinery for fulfilling its purpose.

Paulet combined the directorship of the School with the management of the magazine that he had founded in 1906, *Ilustración Peruana.* This magazine, directed toward youth, was known for its scientific-technical orientation, and had as its objective the preparation of youth for engineering, and especially aeronautical, vocations.

He also turned the magazine into a voice, demanding the attention of the Peruvian government in encouraging and investing in the generation of scientific vocations and in scientific research. Paulet's dissertations at the Society of Engineers, on the advantages to Peru of encouraging education in the sciences and in engineering, were very well known.

The Dec. 7, 1910, edition of *Ilustracíon Peruana),* was dedicated, for example, to reporting on the 1908 construction of the first Peruvian monoplane. The building of this 36-foot monoplane, was carried out by Peruvian engineer Carlos Tenaud Pomar, at the School of Arts and Trades. Educated at the Carnot Lyceum in France, Tenaud came to Lima with Paulet, to collaborate on his project for the school.

Paulet also promoted the founding in Lima of an "aviation club," or "aerostation," to "encourage the efforts of our inventors," and to "inspire our future aeronauts." The magazine regularly supported the activities of the National Pro-Aviation League, which Paulet had also founded. Among its first activities, the League hired young Peruvians who had studied aeronautics in Europe, primarily in France, to come back to Peru to serve as instructors.

The 1910 founding of the National Pro-Aviation League by Paulet, which was directed by Gen. Pedro Muniz, was closely followed by the founding of the Peruvian Air Club, both of which were precursors of the Peruvian Air Force. A prominent member of the League, flight pioneer Juan Bielovucic Cavalier, was among the first to fly across the Alps. In 1913, he brought a French Voisin plane to Peru, which was assembled there with the help of the local experts. It was one of the first airplanes to fly in the skies of South America.

Although Paulet hoped, through his Pro-Aviation League, to win economic backing from the Peruvian government for building his prototype ship, he did not get that support. Four years after getting his school established on firm ground and with renown, at the end of 1910, Paulet decided to return to Europe to seek financing there, and to continue with the development of his aerospace project.

He persisted, despite the fact that World War I and lack of financing conspired against him. Although his family was based in London, Paulet travelled through various European nations, carrying out diplomatic duties for the Peruvian government and seeking, unsuccessfully, to win financing for his project.

Paulet married, and from 1911 to 1919, lived mostly in Paris. Paulet travelled occasionally to other countries, repre-

senting the Peruvian government, particularly at scientific conferences.

Paulet's first five children were born in this period, but it was during a difficult time of great economic hardship. He faced the tragedy of the death by starvation of his two youngest children. In 1920, he moved to London for financial reasons, but the next year, the government of Peru named him consul in Dresden, Germany, where he stayed until 1924.

While Paulet was in Germany, he became familiar with the rocket car experiments of Max Valier, and criticized Valier's design for a spaceship in his 1927 letter to *El Comercio*.

In his 1928 book, *Spaceflight,* Valier writes:

> Paulet's work is even more significant [than earlier attempts] for the present project of development of a rocket ship, as they have proven for the first time—as compared to the few seconds of the burning of powder rockets—that it is possible, by the use of liquid fuels, to construct a rocket engine that would burn for an hour.

In 1965, in preparation for the centenary of Pedro Paulet's birth (in 1974), the Peruvian government named a Commission to investigate the contributions of Paulet, to establish his place among the pioneers of aerospace aviation, and also to resurrect his other contributions, to the education of scientists and engineers in Peru. One of the Commission members was Dr. Manuel del Castillo.

Dr. Castillo contacted Hermann Oberth, requesting to visit the German space pioneer at his home in Feucht. Professor Oberth replied: ". . .The name of Pedro Paulet is known to me, if I have been correctly informed. He has worked chiefly with nitric acid and benzene propulsion motors, until the police forbade it."

In 1929, he was sent to Rotterdam as Peru's consul general. Without losing sight of his objective, he sought the collaboration of several well-known engineers there such as Hans Doerr y Philip, and with them began work again on the construction of his "Paulet Motor" prototype. Years earlier, the first prototype he had built had been damaged by war.

In a letter to European scientists who had asked about his work, written in about 1943, Paulet explained the thermoelectric power system he had proposed for a "moving habitat" in air and space. He also proposed the same system be used "for fixed dwellings, which would eliminate the present necessity of lighting, heating, and providing power from expensive electricity plants. I presented this proposal at a Congress on Rural Housing in Liege, Belgium, in 1930, and many of the attendees, and several newspapers there, were interested in this idea," he wrote.

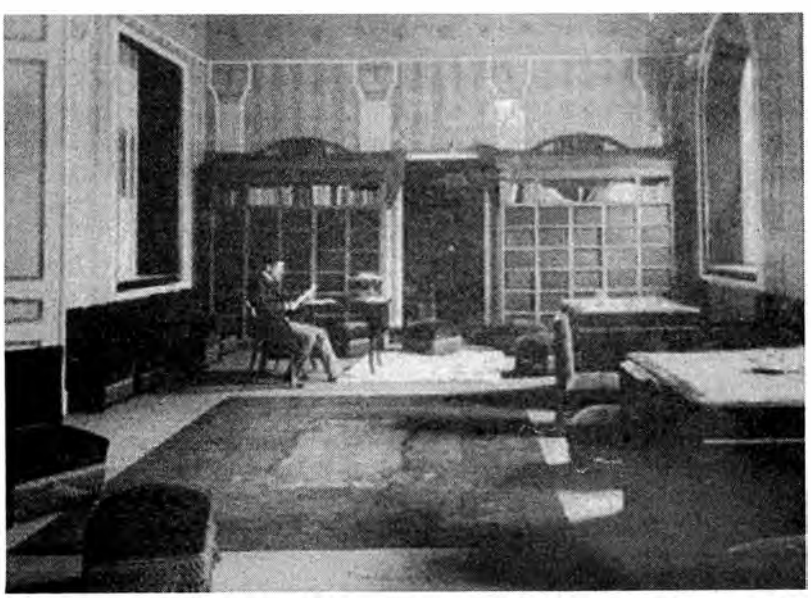
Paulet's work made it into the Rotterdam press. One of the articles about his invention, titled "A New System of Aviation," says in summary:

> There are experiments currently under way in Rotterdam, whose results are going to revolutionize the practice of aerial navigation. Engineer Paulet, after more than 30 years of research and experimentation, is proposing a new system of aerial navigation, based on principles completely different from those currently known and applied. Mr. Paulet's airplane has neither airfoils, nor a winged fuselage, nor a gasoline motor, nor propellers. It is essentially composed of an aluminum spheroid, with a steel interior measuring three-and-a-half meters long and two-and-a-half meters wide. Inside the cabin, similar to that of Swiss Professor August Píccard, which he uses for his studies of the stratosphere, there is room for three or four crew members. . . .

While working on his engine prototype, and on the prototype of his "Torpedo-Plane," Paulet faced new challenges specific to the development of the project, such as the need to provide a permanent supply of energy to the interior of the ship. In this regard, Paulet wrote in his 1931 notes:

> I have come up with a system for a thermoelectric wall which produces electricity in flight. This device is very important, given the enormous difference in temperature that exists between the interior of the vehicle, where temperature has to be normal, and the exterior in the atmosphere, where it is very cold. Thermoelectric batteries are already well known, but what was missing was how to apply them to the provision of electricity in a travelling habitat.

Paulet began to receive recognition by well-known scientists, as the forefather of reaction motors for rocket propulsion. News of his invention went beyond Europe, and in 1928 he received a million-dollar offer from Henry



Pedro Paulet, in his office in Lima, Peru, after a 25-year absence, on various diplomatic missions. Upon his return, he founded, organized, and directed the Trade Department of the Peruvian Foreign Ministry.

Ford, who wanted to "buy" his invention with the idea of adapting the rockets of his "Torpedo-Plane" to his motor cars. Ford suggested that Paulet renounce his Peruvian nationality, and adopt American citizenship, so that his invention could be patented as American. But Paulet rejected the offer because, he said, his "Torpedo-Plane" had been conceived to "navigate 348,000 kilometers of space, until touchdown on lunar soil."

The German Astronautical Society invited Paulet to join a team of scientists to study rocket propulsion, a proposal presented as an opportunity to test his invention. But upon learning that it would be used to fabricate a weapon that could double the range of the "Great Britain Cannon," he rejected the offer.

In the midst of all of this, in 1932, the Peruvian government named Paulet consul general in Yokohama, Japan. While at this post, he studied the Japanese economic model, leading to the publication of a book titled *Modern Japan and Its Economic Foundation.* He also wrote a series of reports for the Peruvian Foreign Ministry, which included proposals for Peruvian development based on the Japanese economic model.

Paulet was called back to work at the Peruvian Foreign Ministry from 1935 to 1941. While there, he returned to building a replica of his "reaction engine" and "Torpedo-Plane," and gave his models to the Aviation Ministry, in the hope of winning financing to continue work on his project. His appeals did not succeed. During this period, he also appealed for support from the British, and gave a set of original drawings and writings on his project to the British Embassy in Peru. He never received a reply, or the return of his originals. In 1941, he was transferred to Buenos Aires for another diplomatic assignment.

In the middle of World War II, Peru broke diplomatic relations with Japan, and Paulet's son (married to a Japanese woman), who had been protecting his reaction motor and Torpedo-Plane prototypes, had to suddenly leave the country. Although put in storage, the prototypes were lost over the years.

Paulet died in Buenos Aires in 1945.

Testament of a Scientist

Years later, when questioned why he had not made his early experiments public at the time, Paulet responded in his letter to European scientists, explaining why there had been little written about his experiments at the time they were carried out:

> Those who witnessed these experiments knew I meant to invent a kind of motor which seemed simpler and more powerful than any known up until that time. But I chose not to publish anything about it, nor to apply for a patent, because even though the rocket seemed perfect to me, the explosive used was very dangerous and my intention was to find a safer and cheaper one.

In his letter to *El Comercio,* Paulet wrote with a scientist's humility:

> Even though I have no information that anyone before me concerned himself with a torpedo rocket plane, I don't seek to claim paternity for this invention, because, as with all projects, it is not valid until it is realized. The inventor of the rocket airplane will be the first one to fly in an apparatus powered by rockets.

The author (left), with Pedro Paulet's daughter, Megan, in 1996. His legacy and accomplishments are an example of the limitless possibilities for all young people in Peru, and around the world.

In the same way, he clarifies, "it is not enough to say that the project of the German [Max] Valier has been preceded, by 30 years at least, and by even perhaps more conclusive experiments, by that of a Peruvian," referring to himself.

Then, in a gesture that revealed his conviction that "genius is not born, but made" and that "every Peruvian child could be a scientist" because all men possess the divine spark of creation, he delegated the continuity of his invention to young Peruvian scientists, saying to them:

> [I want] to call the attention of our nation's technicians and inventors to this important matter. . . . In effect, what I was unable to achieve, through unfortunate circumstances, well might some other, better-provided compatriot obtain, to the glory and advantage of Peru.

Sara Madueño heads the Lima bureau of Executive Intelligence Review *magazine in Peru and is a long-time political collaborator of international statesman Lyndon H. LaRouche, Jr. She notes that this article is in payment of a long-standing debt to Megan Paulet, daughter of Pedro Paulet, and is written in memory of her own mother, Sara Paulet de Madueño, Pedro Paulet's niece. The article was translated into English by Valerie Rush and Carlos Potes.*

Sources and Acknowledgments

My special thanks to Megan Paulet. My discussions with her were the inspiration and first-hand source for the preparation of this article.

The letter to *El Comercio* was written by Pedro Paulet on Aug. 25, 1927, while he was attending a congress in Rome. The entire text of this letter appears as an appendix to the book by Megan Paulet, *Pedro Paulet, Father of Astronomy,* published by the National Council of Science and Technology (CONCYTEC) of Peru, 1988.

The Feb. 1996 exhibit, "Pedro Paulet: Forerunner of the Space Age," at the Institute of Aerospace Historical Studies of Peru, included original drawings of Paulet's inventions. It can be seen today at the Institute's Pedro Paulet Museum, in his native Arequipa, and is the source for the illustrations for this article.

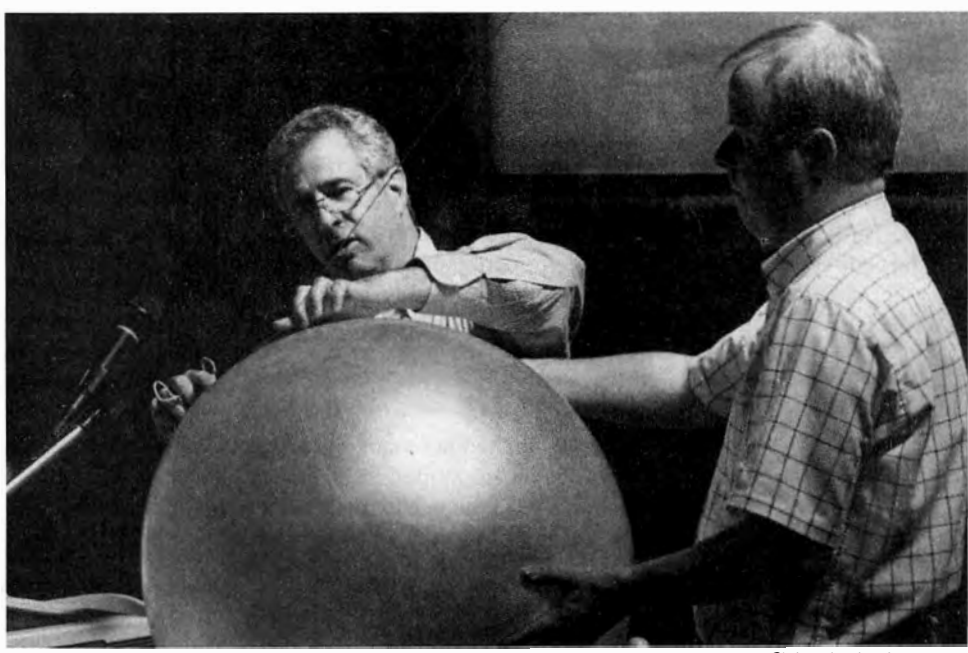
Sketches and full-scale models for the "reaction engine," the "Girándula," and the "Torpedo-Plane," can be seen in the Pedro Paulet Hall of the Aeronautics Museum of the Peruvian Air Force, in Lima, Peru.

The photographs of the sketches and models in this article were taken by Sara Madueño Paulet.

The Division of The Circle and Gauss's Concept Of the Complex Domain

by Bruce Director

The complex plane, as Gauss developed it, is not what you learned in text books.



Christopher Lewis

The author (left) hard at work upon the sphere.

The pursuit of a discovery of a universal principle always requires the pursuer to follow the Socratic method of negation or, as Nicholas of Cusa called it, "Learned Ignorance." That is the method by which Johannes Kepler, for example, ascended from the tangle of observed motions of the planets seen as if projected on the inside of an imaginary sphere, to the "hypergeometric" function which characterized his universe. While the cause of these observations is determined from the top down by that function, like the shadows of Plato's Cave, we cannot know that function directly. Rather, we must look at the gaps in the observations, and discern the hypergeometry underlying those observations.

It is the nature of this method that, as our knowledge of the underlying hypergeometry increases, new gaps appear, through which new characteristics of the hypergeometry become discernible. These new characteristics, in turn, recast the previous discoveries in a new light. For example, the principle that light travels the shortest path, discovered by the Greeks as a characteristic of reflection, becomes a special case of the principle that light travels the path of least time, discovered by Fermat as a characteristic of refraction. In both cases, light acts according to a minimizing principle. But, in the former, that principle is with respect to a manifold of space, while the latter is with respect to a manifold of space-time. It is the manifold from which the characteristic of the path is determined, but it is the characteristics of the path, by which the manifold is discovered.

For more than 2,000 years, it was believed to be impossible to construct a 17-sided regular polygon with straight-edge and compass. But on March 20, 1796, as Carl Friedrich Gauss later

recalled it, after much hard work, the possibility of accomplishing such a construction appeared to him in a flash of insight. Gauss was then 18 years old.

Gauss always considered this one of his most important discoveries, which, accompanied by a provocation from his teacher Abraham Kästner, determined the trajectory of his entire creative life—so much so, that he asked that a 17-gon be engraved on his tombstone. (Because an engraved 17-gon would look so much like a circle, a 17-sided star was engraved instead.)

The more general treatment to which Kästner was guiding Gauss, was the solution of the "Kepler challenge," which concerned the divisibility of the ellipse, a curve of non-constant curvature. In fact, Gauss's method for the division of the circle was based on the discovery that the constantly curved circle, is actually a special case of non-constant curvature.

Kepler's Treatment of the Circle

Gauss's investigation into the division of the circle, was an extension of the study done by Johannes Kepler in the first book of his *Harmonies of the World,* "On the Regular Figures, the Harmonic Proportions They Create, Their Source, Their Classes, Their Order, and Their Distinction into Knowability and Representability." It is here that Kepler started his elaboration of the harmonic ordering principle that governs the physical universe. "We must seek the causes of the harmonic proportions in the geometrical and knowable divisions of a circle into equal number of parts," he began.

To divide the circle by geometrical means, according to Kepler, is to determine the ratio of the side of the figure to the diameter. It is in the efforts to divide the circle, that the human mind discovers the different types of harmonic proportions, which Kepler ranked according to degrees of knowability.

The first degree of knowability pertains to those quantities which can be proven equal to the diameter. The second degree of knowability pertains to those quantities that can be proven to be equal to parts of the diameter. The third degree of knowability pertains to those quantities that are inexpressible in length but expressible in square. From this follows those quantities that are inexpressible, or as the Greeks called them, incommensurable. However, the ranking continues among the types of incommensurables. The fourth degree of knowability pertains to those lengths that are not expressible by squares, but are expressible as rectangles. Kepler continued, following the Tenth Book of Euclid, to enumerate the further degrees of knowability of the incommensurable.

What is significant for us, is that Kepler is reasserting the knowability of incommensurable magnitudes, not only in the context of geometry, but as the very magnitudes by which the physical universe is characterized. Here Kepler carried out a strenuous polemic against Petrus Ramus (1515-1572), a leading Aristotelian of the day, who had sought to ban incommensurable magnitudes, not only from the physical universe, but from geometry as well!

As we will see shortly, it is in the division of the circle that we encounter these different degrees of knowability. This raises the following question: If the circle is, at it appears to the eye, a perfectly uniform, constantly curved figure, why, when one attempts to divide it, does one encounter magnitudes of different degrees of knowability? The reader should think of the different types of magnitudes necessary to construct a triangle, square, pentagon, hexagon, and heptagon, for example. Each different division of the circle gives rise to different degrees of knowability, and some divisions, such as seven, seem to be unknowable altogether.

This is the question that Kepler investigated in the *Harmonies of the World.* The question the young Gauss investigated was, "What is the principle that governs the principle of knowability?"

Paradox of the Circle

Magnitudes of the first three degrees of knowability, are also called constructible (Figure 1), because they can be constructed from the circle itself, or to put it colloquially, by straight-edge and compass (the straight-edge being the diameter and the compass being the circumference of the circle). It is in the investigation of what is constructible, that we discover a gap, an anomaly, through which we ascend to the idea that the seemingly uniform circle is, in fact, not uniform at all, but a special case of non-uniform action!

Ancient Greek philosophers had fully investigated the fact that, although the circle is uniform in all its parts, it does not

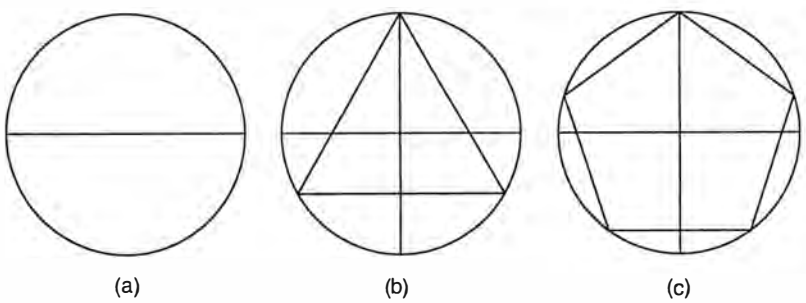


Figure 1
THE DEGREES OF KNOWABILITY

In the first book of the Harmonies of the World, *Kepler showed that the divisions of the circle generate a hierarchy of types of magnitudes. Using the terminology from Book X of Euclid's* Elements, *he demonstrated that the division of the circle by the diameter produces magnitudes of the first degree of knowability (a), those divisions measurable by a part of the diameter produce the second degree of knowability (b), and those divisions whose squares, fourth powers, and other combinations are measurable by the diameter, produce the third degree of knowability (c).*

Such differentiation seems strange to the modern reader, because Kepler's opponent, Petrus Ramus, and his followers were successful in removing the study of Euclid's Book X from the schoolrooms.

divide uniformly. The circle can be divided into two parts by folding in half. By folding in half again, and again, the circle can be divided into 2, 4, 8, 16, and so on, parts. But to divide it into three parts—that is, to inscribe a triangle in it—requires the generation of a magnitude of the second degree of knowability. (Half the diameter is the side of a hexagon.)

Once that magnitude is created, it too can be doubled, to produce a division by 6, 12, 24, and so on, parts. But to divide the circle into five parts, requires the generation of a magnitude of a higher degree of knowability, specifically, the golden section. The golden section is not commensurable with the diameter, or with a part of the diameter, but it is constructible.

However, it had been believed for more than 2,000 years, that all other divisions of the circle were non-constructible. In other words, those divisions of the circle based on prime numbers greater than 5, depended on magnitudes that were beyond Kepler's degrees of knowability. This boundary condition suggests that something outside the circle, a higher principle, is governing. It is that principle that Gauss sought.

To discover this principle, Gauss, in effect, inverted the problem altogether. Instead of thinking of two different types of magnitudes, constructible and non-constructible, he investigated a general principle governing the generation of magnitudes, of which the constructible ones were a special case. (A suggestive example of this concept was supplied by Lyndon H. LaRouche, Jr., several years ago, when he posed the possibility that the number 5 associated with the hypotenuse of a 3-4-5 right triangle, should be considered a special type of irrational number.)

Additionally, Gauss used a unique application of geometry of position, which at first may seem obscure. He inverted the conception of the circle. Instead of beginning with the circle and trying to find those positions that divided it, he sought the functions that created a divided circle. Thus, the positions were produced by the division, not the division by the positions.

Gauss showed that both the above principles relied on two, seemingly unrelated, conceptions that were at the heart of Greek science, and had been extended by the work of Kepler, Leibniz, Bernoulli, and Fermat: the geometric generation of incommensurables, and the more shrouded principles governing the generation of prime numbers. And, spurred by Kästner's prodding, Gauss showed that these principles extended beyond the circle.

As Gauss described it in the opening of the final chapter of his *Disquisitiones Arithmeticae:*

Gauss and His Teacher

From 1792 to 1795, Carl Friedrich Gauss received his early education at the classically oriented Collegium Carolineum in Brunswick-Wolfenbüttel. The curriculum consisted of ancient and modern languages, classical sciences, aesthetics, poetry, music, and art.

On Oct. 11, 1795, he left for Göttingen, where he was attracted to the study of philology, under Christian Gottlob Heyne. The philology seminar at Göttingen had been founded by Johann Matthias Gessner, a former colleague of J.S. Bach at the St. Thomas School in Leipzig. Heyne was Gessner's successor. Also teaching at Göttingen was Abraham Gotthelf Kästner, one of a group of intellectuals dedicated to reviving the thinking of the universal genius Gottfried Leibniz (1646-1716), whose reputation and memory had been destroyed by the oligarchical faction that placed George I of Hannover on the British throne. Kästner's circle also hosted the American universal thinker, Benjamin Franklin, when he visited Germany. Kästner, who came from Leipzig in 1750, was Gauss's mathematics professor at Göttingen.

In a later letter to his Collegium professor E.A.W. Zimmermann, Gauss said that he was particularly attracted to the philology lectures of Heyne and wished to concentrate on the subject. Initially, he thought Kästner was a dull old man, but, "I have since realized I was in error and that he is quite an extraordinary man."

In May 1796, Gauss told Zimmermann in a letter that he had decided to devote himself to mathematics after discovering the constructibility of the 17-gon. When he first showed his discovery to Kästner, the teacher was not at all impressed, and Gauss interpreted this as hostility to something new. Gauss persevered, and when he discussed the concept further, Kästner was astounded, but responded that the discovery would be of no use, and that he (Kästner) had already developed the basis for the discovery in his "Beginning Foundations of the Analysis of Finite Magnitudes." Gauss persisted further, obtaining Kästner's agreement to review the paper.

After further contemplation, Gauss realized that he had to separate Kästner's criticism concerning the discovery's practical use, from the rest of Kästner's reaction. Gauss wrote Zimmermann that Kästner had told him that if he "were to be able to give a more general treatment of the subject, it would be of pleasing curiosity and perhaps produce a brighter insight into this area of mathematics." Gauss told Zimmermann that he took Kästner's judgment entirely to heart.

The Granger Collection

Gauss's professor of mathematics at Göttingen, Abraham Gotthelf Kästner, who was a Leibnizian and a friend of Benjamin Franklin.

Among the most splendid developments contributed by modern mathematicians, the theory of circular functions without doubt holds a most important place. We shall have occasion in a variety of contexts to refer to this remarkable type of quantity, and there is no part of general mathematics that does not depend on it in some fashion. . . . I will speak of the theory of trigonometric functions as related to arcs that are commensurable with the circumference, or of the theory of regular polygons. . . . The reader might be surprised to find a discussion of this subject in the present work which deals with a discipline apparently so unrelated; but the treatment itself will make abundantly clear that there is an intimate connection between this subject and higher Arithmetic.

The principles of the theory which we are going to explain actually extend much farther than we will indicate. For they can be applied not only to circular functions but just as well to other transcendental functions. . . .

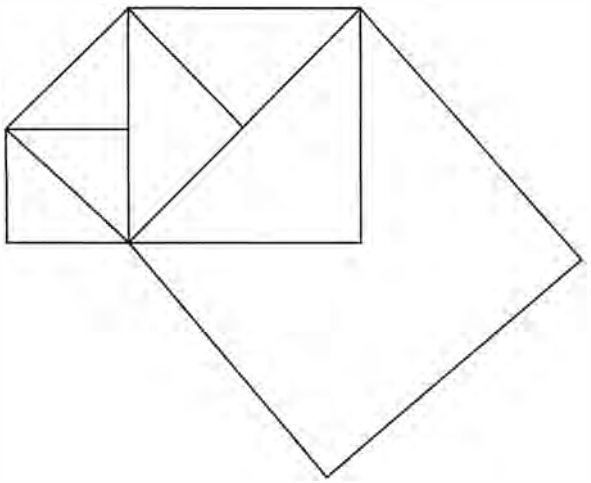


Figure 2
DOUBLING THE SQUARE PRODUCES THE GEOMETRIC MEAN

As Plato demonstrated in the Meno *dialogue, a square of double area may be constructed by building a new square on the diagonal of the first. But the side of the second square will be incommensurable with the side of the first. The Greeks called the diagonal the* geometric mean *between two such squares. Here, a sequence of doubled squares is shown.*

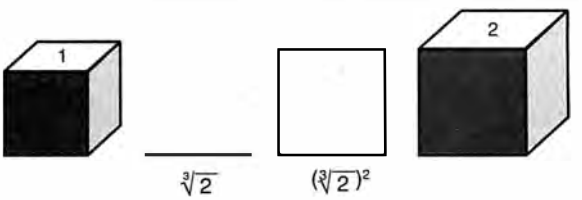


Figure 3
DOUBLING THE CUBE

The diagonal of a cube does not produce a cube of double the original volume. How to double the cube, known as the Delian problem, occupied the leading Greek mathematicians for some time. In the Timaeus *dialogue, Plato reports the discovery of Hippocrates of Chios that there must be two means between the original and the doubled cube, and the lesser of these two means will be the length needed to form the edge of the doubled cube.*

We illustrate this here with the original cube of volume 1, the lesser mean (cube root of 2), the greater mean (the square built on the cube root of 2), and the doubled cube.

The first principle of Greek geometry that Gauss reworked, is described by Plato in his dialogues the *Meno,* the *Theaetetus,* and the *Timaeus.* It concerns the generation of incommensurable magnitudes as a consequence of a change in dimension. The reader can construct a geometrical representation of this by drawing a square, then drawing its diagonal, and then drawing a new square using the diagonal for its side. As Plato demonstrated in the *Meno,* the second square will have twice the area of the first, but the side of the second square will be incommensurable with the side of the first. (In Kepler's terms, the diagonal will be the third degree of "knowability.")

If you continue this drawing, you will produce a spiral sequence of squares whose sides are the diagonals of the previous squares, and whose areas are double the previous squares. The Greeks called the diagonals the "geometric mean" between the two squares (Figure 2).

However, something new develops if you try to replicate this process in three dimensions, as in the case of doubling a cube (Figure 3). The diagonal of the cube does not correspond to the side of a cube with double the volume. This is the famous problem the Delian priests brought to Plato. Eratosthenes reports Plato's famous rebuke, that the gods had posed this problem to the Greeks, because they wanted to chide the Greeks into studying geometry in order to improve their thinking. Hippocrates of Chios had shown that the incommensurable associated with the doubling of the cube, was of a different species than the incommensurable associated with the doubling of the square. In other words, a change in dimensionality, produced a different species of incommensurable.

In the *Timaeus,* Plato reports Hippocrates' discovery:

> But it is not possible that two things alone be joined without a third; for in between there must needs be some bond joining the two. . . . Now if the body of the All had had to come into being as a plane surface, having no depth, one mean would have sufficed to bind together both itself, and its fellow-terms; but now it is otherwise, for it behooved it to be solid in shape, and what brings solids into harmony is never one mean, but always two [Figure 3].

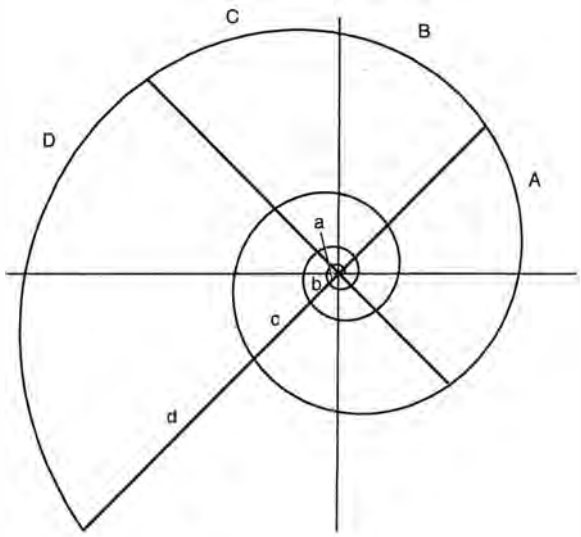


Figure 4
SPIRA MIRABILIS

Johann Bernoulli called the logarithmic spiral spira mirabilis *for all its miraculous properties. Among these are that lines emanating from the center of the spiral at equal angles from each other will cut the spiral into parts that are in geometric proportion. Thus, A:B = B:C = C:D. Also, a line extending from the center of the spiral is cut by the spiral arms in geometric proportion. Thus, a:b = b:c = c:d.*

Gauss accomplished his division of the circle, and then developed his concept of the complex plane by thinking of the circle as a special case of this spiral.

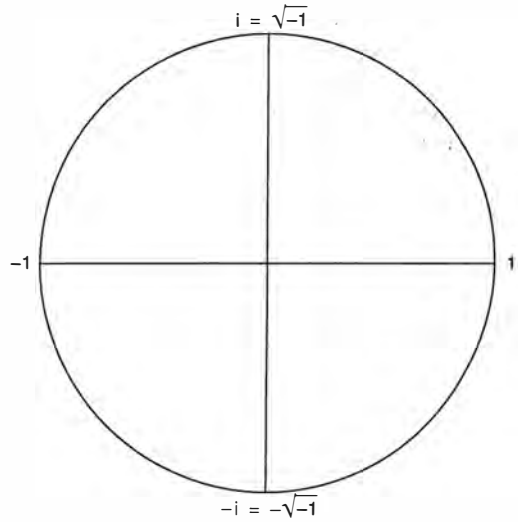


Figure 5
THE COMPLEX DOMAIN

Gauss's concept of the complex domain was built on the Platonic principles of magnitude and Bernoulli's spiral. To divide a circle into four parts in the complex domain, we pick a point on the circumference for the first vertex, and call it 1. The other three points will all be in geometric proportion to each other, and come back around to 1. This is accomplished by multiplying each time by the square root of minus 1, a quantity designated as i.

By inversion, if two or more geometric means are required to double a magnitude, the doubling of that magnitude is an action that originates in a dimensionality greater than two.

Gauss's insight rested on these Platonic principles, with a crucial extension supplied by Johann Bernoulli's discovery of the equi-angular spiral, which he called *spira mirabilis* (miraculous spiral). Bernoulli showed that this spiral was an exemplar of geometric growth. For example, a line extending from the center of the spiral outward, will be cut at different intervals by each spiral arm. These intervals will be in the same proportion to one another, as the areas and diagonals of Plato's squares. Similarly, lines emanating from the center of the spiral at equal angles from each other, will cut the spiral arms in geometric proportion. Thus, equal divisions of the spiral cut the spiral into parts that are in geometric proportion (Figure 4).

Now, if we think of the circle as being a special case of the spiral, then the division of the circle by lines (radii) emanating from the center at equal angles, cuts the circumference in arcs that are in geometric proportion. The intersections of these lines with the circumference correspond to the vertices of an inscribed polygon. Thus, to divide the circle into *n* parts, corresponds to finding n–1 geometric means. Those divisions that can be accomplished by finding one mean between two others, are constructible; and those requiring two or more means are not. Thus, the different divisions of the circle are actually projections of action originating in manifolds of higher dimensionality, than the seemingly two dimensions of the circle.

Again, like the shadows of Plato's Cave, or "Learned Ignorance," we can ascend to knowledge of those manifolds, only from the anomalies embedded in their reflection.

Gauss showed that these anomalies can be discovered, if we think of the circle, not in a Euclidean/Cartesian plane, but in the complex domain. A simple example is, perhaps, the easiest way to illustrate the point. To divide a circle into four parts, first think of the circle in the complex domain. Pick a point on the circumference for the first vertex, and call it 1. To divide the circle into four parts we would mark off three other points that are 90° from each other. According to what we said above from Bernoulli and Plato, these points are all in geometric proportion to each other. Expressed in numbers, these points form a cycle of geometric means from 1 to –1. Using the letter *i* to denote the square root of –1, that series is 1, *i*, –1, *–i*. These four numbers produce a cycle, such that if you multiply each one by itself 4 times, you get 1 (Figure 5).

Gauss's insight was based on the following: Dividing the

circle into *n* parts requires finding *n–1* geometric means between 1 and 1. Kepler had already indicated this direction in the first book of the *Harmonies of the World.* There, Kepler showed that the construction of the pentagon depended on the construction of an isosceles triangle whose base angles are double the top angle. After inscribing this triangle in a circle, the pentagon is constructed by bisecting the base angles, which form the diagonals of the pentagon. Each diagonal cuts the sides of the original triangle into two proportional sections (Figure 6).

Kepler then shows that the heptagon is constructed from an isosceles triangle whose base angles are three times the top angle. To construct the heptagon requires trisecting the base angles, or cutting the sides of the triangle into 3 proportions (Figure 7). Kepler concludes that to construct a polygon of *n* sides requires being able to cut a line into (n–1)/2 proportions. Gauss discovered the general principle by which this is done.

Gauss showed that these combinations of cycles correspond to Plato's principle of means. Those divisions that can be resolved completely into cycles of two, correspond to inserting one geometric mean between two others, as in doubling of the square, and are therefore constructible. Those prime number divisions that cannot be so resolved, correspond to inserting two or more geometric means, and, like the doubling of the cube, are not constructible. Thus, it is possible to construct figures of 2, 3, 5, 17, 257, 65,537 and any other prime number divisions of the form $2^{2^n}+1$. All other divisions cannot be constructed because they are reflections of actions of a dimensionality higher than two.

It is the thinking underlying the above discovery of Gauss, that is at the heart of Gauss's and Riemann's development of the theory of functions.

Bruce Director is a leading collaborator of Lyndon H. LaRouche, Jr. and a director of the Constitutional Defense Fund. A version of this article appeared in the weekly New Federalist *as Parts 11 and 12 of a series "Riemann for Anti-Dummies."*

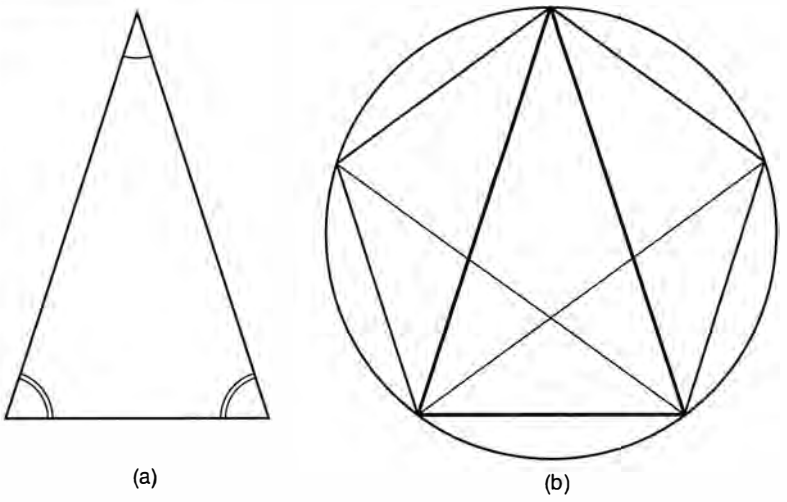


Figure 6
DIVISION OF CIRCLE INTO FIVE PARTS

To divide the circle into five equal parts, that is, to construct the pentagon, requires that we construct an isosceles triangle whose base angles are twice the apex angle (a). Such a procedure, which requires the division of a line in a proportion known as mean and extreme (the golden section), was known to the Greeks.

This done, we inscribe the triangle in a circle (b). Kepler noted that each of the base angles will then subtend a circular arc equal to two sides of the pentagon, while the apex angle subtends an arc of half that length. Now, we can bisect the base angles, producing the five divisions of the circle.

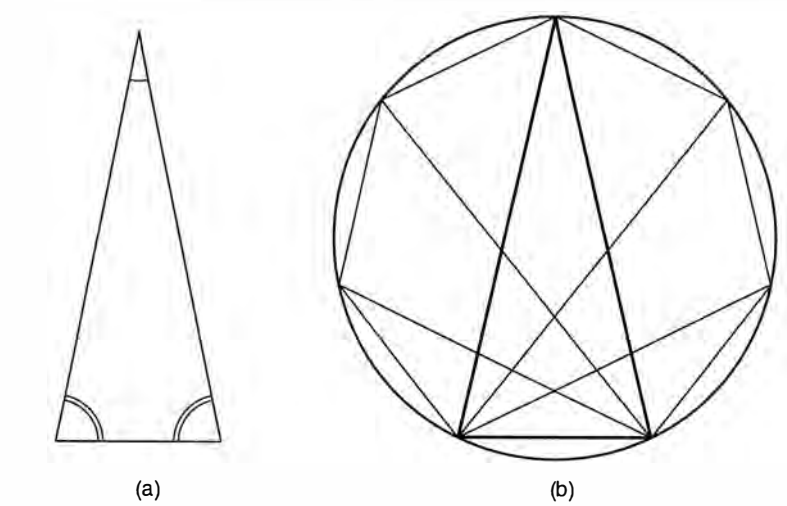


Figure 7
THE IMPOSSIBLE HEPTAGON

To divide the circle into seven equal parts, that is, to construct the heptagon, would require the construction of an isosceles triangle whose base angles are three times the apex angle (a). But this is provably unconstructible. If such a triangle were constructed, it would be necessary to trisect its base angles (b) in order to divide the circle into seven equal arcs. Thus Kepler showed that the impossibility of constructing the heptagon is related to the impossibility of trisecting an angle.

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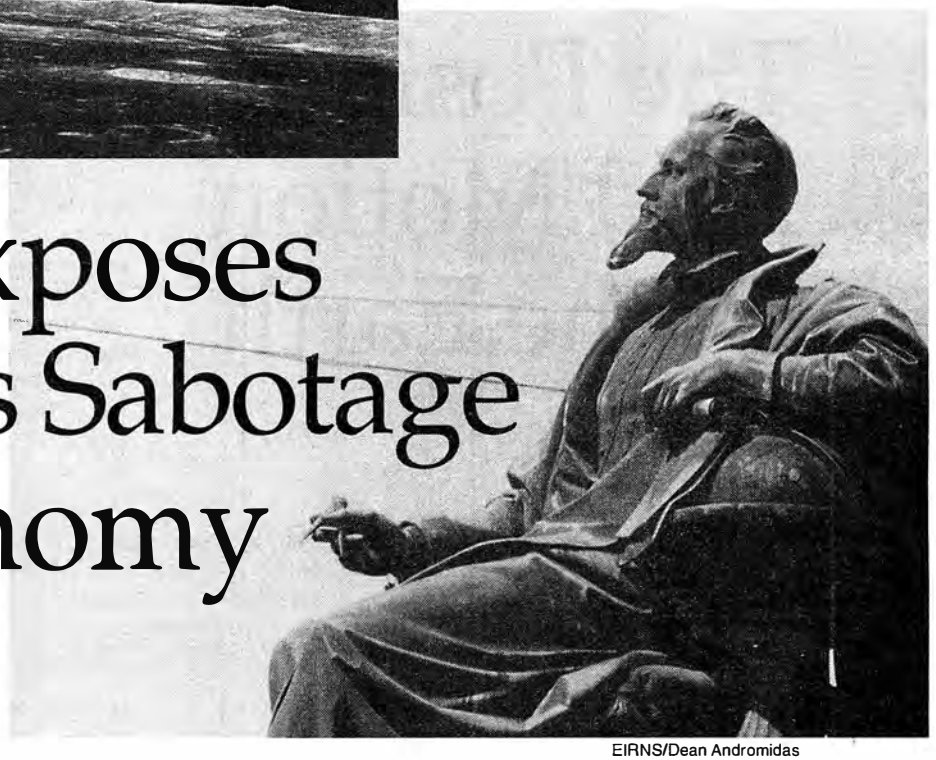

The founder of modern astronomy, Johannes Kepler (1571-1630).

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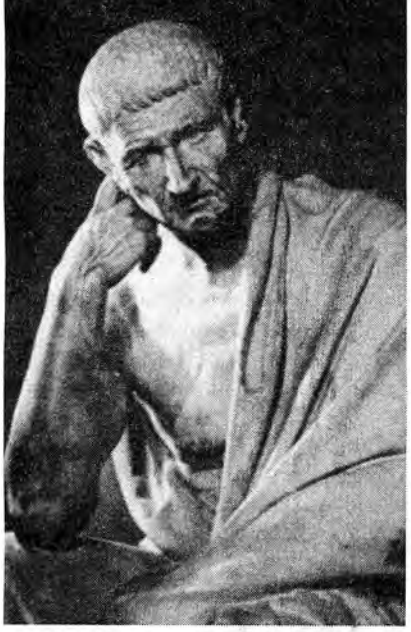
Kepler Exposes Aristotle's Sabotage Of Astronomy

Kepler charged Aristotle with 2,000 years of sabotage of science, for using a false argument to insist that the Sun must orbit a stationary Earth.



A Greek statue of Aristotle (384-322 B.C.) now in a Vienna museum.

EDITOR'S NOTE

In a little known document, the founder of modern astronomy, Johannes Kepler (1571-1630), refuted Aristotle's geocentric cosmology, point by point. In that refutation, Kepler charged that Aristotle (384-322 B.C.), with his immense prestige, held science back for two millennia by rejecting—with a specious argument—the idea of the Pythagoreans that the Earth moves in an orbit. Kepler's repeated reference to the concept of universal gravitation (points 12-14, 28-33), is to be noted, especially by those who still believe the Isaac Newton myth. An incomplete version of this document was published in a 19th Century edition of Kepler's astronomical works, and it finally appeared in a scholarly edition by Fritz Rossmann in 1948. The document consists of Kepler's translation into German of Chapters 13 and 14 of Aristotle's On the Heavens, *and his refutation in 35 points, also in German, keyed to passages in Aristotle's text. Kepler's choice of German may have reflected a desire to take the issue of cosmology to a socially broader audience than the churchmen and scholars who read Latin and often Greek, and suffered from a strong bias in favor of Aristotle.*

It seems clear, however, that Kepler never completed the project. The work was not published in Kepler's lifetime, and only one manuscript is known. (It is in the extensive collection of Kepler manuscripts in the Pulkovo Observatory Library, at the University of St. Petersburg, Russia.) Its editor, Rossmann, considers the manuscript a first, or—at most—a second draft. It is in Kepler's own hand. Rossmann notes its hasty hand and its many insertions, deletions, revisions, and writing errors.

When did Kepler produce it? Because of its references to Galileo's discoveries in points 4 and 5, we can be sure it was completed after 1611. The choice of language in the reference to Aristarchus as being indicted before "the Athenian heathen pope and priesthood," in point 4, suggests that it was not completed before the condemnation of the Copernican system by the Catholic Church in 1616.

Here, we present George Gregory's first English translation of Kepler's refutation, alongside Aristotle's text. In an Afterword (p. 39), Gregory discusses what Aristotle did and did not know, the modern attempt to discredit Kepler's argument against Aristotle, and related issues.

Aristotle on The Position And Motion Of the Earth

Chapter 13 (293a13 ff.)

It remains to speak of the Earth, of its position, of the question of whether it is at rest or in motion, and of its shape.

I. As to its *position,* there is some difference of opinion. Most people—all, in fact, who regard the whole heaven as finite—say it lies at the center.**[1]** But the Italian philosophers known as Pythagoreans, take the contrary view. At the center, they say, is fire, and the Earth is one of the wandering stars,**[2]** creating day and night**[3]** by its circular motion about the center. They further construct another Earth in opposition to ours, to which they give the name counter-Earth.**[4]** In all this, they are not seeking for theories and causes to account for observed facts, but rather forcing their observations and trying to accommodate them to certain theories and opinions of their own. But there are many others who would agree, that it is wrong to give the Earth the central position, looking for confirmation rather to theory than to the facts of observation. Their view is, that the most precious place befits the most precious thing: but fire, they say, is more precious than Earth, and the limit than the

A translation of Chapters 13 and 14 of Aristotle's On the Heavens, *taken—with slight amendments—from John L. Stocks's translation of the whole work* (De Caelo, *Oxford: Clarendon Press, 1922). Aristotle's text continues on the top half of the page. Numbers in square brackets key the text to Kepler's refutation-points, which appear on the bottom half.*

Johannes Kepler's Objections To Aristotle

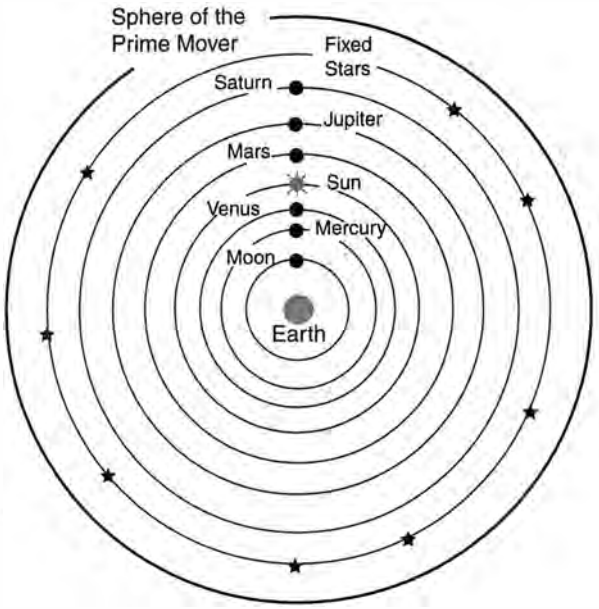
1 Were the heaven infinite, the center of it could nowhere be shown.

2 They spoke in a veiled way, by fire they understood the Sun, and I agree with them, that the Sun is in the center of the world, and never moves away from this place, and that, on the other hand, the Earth moves once in one year around the Sun, that is, it revolves around the center position of the world, as otherwise also five other wandering stars [that is, the planets], with this order: Mercury which is the closest to the Sun, and the fastest, completes its orbit in one quarter year. Venus is the other, revolves around the Sun and around the orbit of Mercury in two-thirds of one year, or in eight and one half months. Now follows the Earth as the third, which revolves around the Sun, also around the two orbits of Mercury and Venus, further distant in a larger orbit, and completes its revolution in one year. Upon this follows the fourth, namely Mars, which revolves in a larger orbit surrounding that which the Earth traverses, in two years less one and one-half months. Still more distant revolves Jupiter, the fifth, and completes its revolution in 12 years. The most distant and sixth in number, which also has the largest orbit, is Saturn, which completes its revolution in 30 years. All of this was taught 2,000 years ago, since Aristotle was born that long ago; and Archimedes, in the book which he wrote on the *Sand of the Sea,* how many grains there are, reports on a learned astronomer, Aristarchus, a countryman of Pythagoras, also born upon the island of Samos, and who lived some hundred years after Aristotle, and 150 years before Archimedes, 1,900 years before us, that he also taught the same things: namely that high heaven with the fixed or attached stars,* together with the Sun, are unmoved, but the Earth is led around the Sun in an orbit, which runs between the orbits of the other planets, and so on. That is described in sufficient clarity, for the orbit in which the Earth revolves, has within it those of Venus, Mercury and the Sun, and beyond it, those of Mars, Jupiter, and Saturn, and thus lies among the orbits and orbiting planets.

As now this teaching is already more than 2,000 years old, we may properly be surprised, that Copernicus, one hundred years ago, once again developed the very same teaching himself, because he knew nothing of how the ancients thought.

* The fixed stars—which we call simply stars—are to be distinguished from the wandering stars or planets. The fixed stars do not change their places relative to one another, while the wandering stars move among them on the sky [ed.].

intermediate, and the circumference and the center are limits. Reasoning on this basis, they take the view, that it is not Earth that lies at the center of the sphere, but rather fire. The Pythagoreans have a further reason. They hold, that the most important part of the world, which is the center, should be most strictly guarded, and name it, or rather the fire[5] which occupies that place, the "Guard-house of Zeus," as if the word "center" were quite unequivocal, and the center of the mathematical figure were always the same with that of the thing or the natural center. But it is better to conceive of the case of the whole heaven as analogous to that of animals, in which the center of the animal and that of the body are different. For this reason, they have no need to be so disturbed about the world, or to call in a guard for its center: rather let them look for the center in the other sense,



ARISTOTLE'S GEOCENTRIC UNIVERSE
The Earth was the center of Aristotle's universe, with the Moon, the planets, the Sun, and the fixed stars rotating in concentric circles. The outermost sphere in Aristotle's system was that of the Prime Mover, who caused a rotation in his sphere, which, in turn, caused the other spheres to rotate.

Johannes Kepler was one of the most powerful, productive, and playful minds of all time. His works are suffused with his love of God and passion for the life of the mind in the pursuit of truth. This portrait is by his contemporary, Jacob van der Heyden.

Since, had *he* not discovered out of his own mind how the orbit of the Earth is constituted, *we* would not have discovered how the ancients thought, even if we had read their words.

3 This is false, Aristotle did not understand the learned teaching of the Italians. For, in addition to revolving around the Sun, the Earth also itself revolves, and by this revolution it makes day and night. For when a place on Earth revolves away from the light of the Sun, it is night at that place. But it revolves 365 times before it revolves once around the Sun. If one mixes the two movements together, it resembles a bowling ball—it rolls and revolves on the ground, and also moves its way forward toward the pins. Similarly, by moving around the Sun, the Earth does not create day and night, but by means of both, by its orbit and its well-ordered revolution, it makes Summer and Winter.

4 Again Aristotle has forgotten the Pythagorean way and custom, that they kept this teaching secret, and spoke of it veiled, so that no one would understand it, except those who belonged to them. By the word counter-Earth, they meant the Moon, for it is also another Earth, but one which is contrary to our own, and one which revolves around ours. And this is not only because one sees in the Moon valleys and mountains, water and land, as we have on our Earth. But it is also especially because the Moon has no primary planets for itself which would make their own orbit around their sun, but it avails itself of this orbit, in which the Earth is driven, and it also moves in this orbit, and is thus also led around the Sun. But, unlike the Earth, as if it were to follow or precede in the footsteps of the Earth, however, it revolves alone each month twice through the path of the Earth, once in front, once behind it, and furthermore makes its orbit around the Earth as if it stood still, no differ-

and tell us what it is like and where nature has set it.**[6]** That center will be something primary and precious; but to the mere position we should give the last place rather than the first. For the middle is what is defined, and what defines it is the limit, and that which contains or limits is more precious than that which is limited,**[7]** seeing that the latter is the matter and the former the essence of the system.

II. As to the position of the Earth, then, this is the view which some advance, and the views advanced concerning its *rest or motion* are similar. For here, too, there is no general agreement. All who deny, that the Earth lies at the center think, that it revolves about the center, and not the Earth only, but, as we said before, the counter-Earth as well. Some of them even consider it possible, that there are several bodies so moving, which are invisible to us owing to the interposition of the Earth. This, they say, accounts for the fact, that eclipses of the Moon are more frequent than eclipses of the Sun: for in addition to the Earth, each of these moving bodies can obstruct it.**[8]** Indeed, as in any case the surface of the Earth is not actually a center, but distant from it a full hemisphere, there is no more difficulty, they think, in accounting for the observed facts on their view, that we do not dwell at the center, than on the common view, that the Earth is in the middle. Even as it is, there is nothing in the observations to suggest that we are removed from the center by half the diameter of the Earth.**[9]** Others, again, say that the Earth, which lies at the center, is "rolled", and thus in motion, about the axis of the whole heaven. So it stands written in the *Timaeus*.*

III. There are similar disputes about the *shape* of the Earth. Some think it spherical, others that it is flat and drum-shaped.**[10]** For evidence, they bring the fact that, as the Sun rises and sets, the part concealed by the Earth shows a straight and not a curved edge, whereas if the Earth were spherical, the line of section would have to be circular. In this they leave out of account the great distance of the Sun from the Earth and the great size of the circumference, which, seen from a distance on these apparently small circles, appears straight.**[11]** Such an appearance ought not to make them doubt the circular

* This remark of Aristotle's is typical of the caution which often accompanies his lies or omissions: he did not write that what is written in the *Timaeus* is the view of Plato [ed.].

ently than the Earth and the other five planets make their orbits around the still-standing Sun. The Earth is as a rider who makes his way forward, the Moon is as a snail or a bee, which buzzes around the heads of the rider and his steed, sometimes in front, sometimes behind, or, as a dog is wont to do, moving to and fro. If, thus, the Moon is an Earthly planet, created to serve the Earth, Jupiter has four of these, Saturn two, as far as has been discovered with telescopes thus far. And this is the reason why the old Pythagoreans called the Moon the counter-Earth.

But it is in nothing peculiar of Aristotle that he speaks of the Pythagoreans here so derogatorily. They perhaps deserved it in diverse other respects, as for example that they ate no beans, and that they came to diverse silly conclusions from the appearance, the form and the nature of beans; it is not peculiar, I say, that Aristotle rejected this as an old wives' tale: another witty fellow, as strong as a tree, a philosopher by the name of Cleanthes, who chiefly cleared land and dug stumps, so that he could earn his bread with hard daily work and carrying water from the well, and now and then was even able to study, this man, I say, treated the poor Aristarchus still worse, indicted him before the Athenian heathen pope and priesthood, accused him of heresy, and demanded that he be punished by death because he supposedly displaced the goddess of idolatry, Vesta, from her altar.** For Vesta was thought to be the goddess of the Earth, which is her hearth, such as is built in the middle of every house, sacred and consecrated, and he who dishonors the hearth has sinned against the god. And since now Hearth meant

Cardinal Bellarmine

KEPLER VERSUS ARISTOTLE

Cardinal Nicholas of Cusa wrote that the Earth moved around the Sun in his Of Learned Ignorance, *1437-1440. Pope Clement VII and Cardinal Nicholas Schonberg gave thought to Copernicus' work in the 1530s. Yet the Catholic Counter-Reformation, imbued with the spirit of Aristotle, caught up with heliocentrism and induced the Church to condemn it in 1616. In 1619, Kepler's works were placed on the Index of Prohibited Books—itself a product of the Counter-Reformation.*

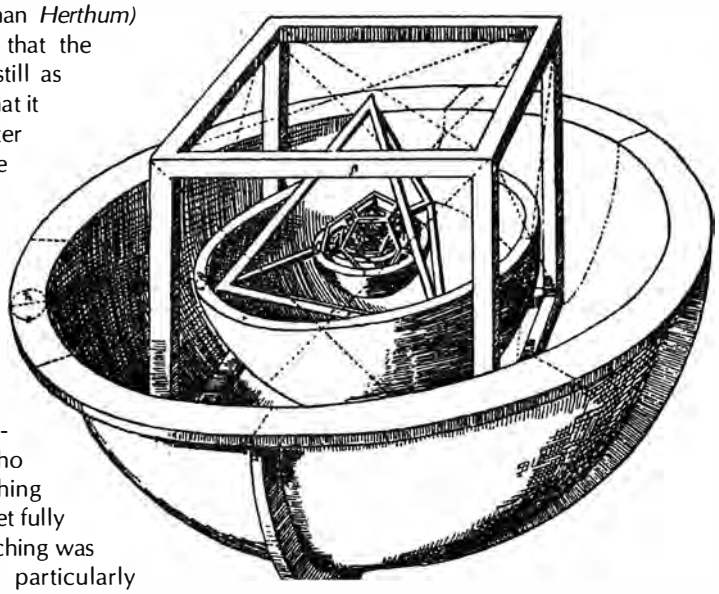
The influential Cardinal Robert Bellarmine of the Roman Inquisition, shown here, played a key role in the condemnation. Bellarmine quoted the Bible to "prove" that the Sun, not the Earth, moved: The Sun "rejoiceth as a strong man to run a race. His going forth is from the end of the heaven, and his circuit unto the ends of it" (Psalms 19:4-6).

** Here, Kepler, a Protestant, is likening the rulers of Athens to the Roman Catholic pope and priesthood for polemical effect, calling to mind the Church's insistence on the Aristotelian cosmology. (Although Lutheran authorities generally concurred, they had less power.) Protestants charged Catholics with idolatry, so Vesta becomes the goddess of the Athenian idolaters. Vesta was actually the ancient *Roman* goddess of the hearth. Her Greek equivalent was Hestia [ed.].

shape of the Earth. But they have another argument. They say that, because it is at rest, the Earth must necessarily have this shape. For there are many different ways in which the movement or rest of the Earth has been conceived.

The difficulty must have occurred to everyone. It would indeed be a complacent mind that felt no surprise that, while a little bit of Earth, let loose in mid-air, moves and will not stay still,**[12]** and the more there is of it, the faster it moves, the whole Earth, free in mid-air, should show no movement at all.**[13]** Yet here is this great weight of Earth, and it is at rest. And again, from beneath one of these moving fragments of Earth, before it falls, take away the Earth, and it will continue its downward movement with nothing to stop it.**[14]** The difficulty then, has naturally passed into a commonplace of philosophy; and one may well wonder, that the solutions offered are not seen to involve greater absurdities than the problem itself.

By these considerations, some have been led to assert, that the Earth below us is infinite, saying with Xenophanes of Colophon, that it has "pushed its roots to infinity,"—in order to save the trouble of seeking for the cause. Hence the sharp rebuke of Empedocles, in the words "if the deeps of the Earth are endless and endless the ample aether—such is the vain tale told by many a tongue, poured from the mouths of those who have seen but little of the whole." Others say the Earth rests upon water. This, indeed, is the oldest theory which has been preserved, and is attributed to Thales of Miletus. It was supposed to stay still because it floated like wood and other similar substances, which are so constituted as to rest upon water, but not upon air. As if the same account had not to be given of the water which carries the Earth itself! It is not the nature of water, any more than of Earth, to stay in mid-air: it must have something to rest upon. Again, as air is lighter than water, so is water than Earth: how can they think, that the naturally lighter substance lies below the heavier? Again, if the Earth as a whole is capable of floating upon water, that must obviously be the case with any part of it. But observation shows that this is not the case. Any piece of Earth goes to the bottom, the quicker, the larger it is. These thinkers seem to push their inquiries some way into the problem, but not so far as they might. It is what we are all inclined to do, to direct our inquiry not by the matter itself, but by the views of our opponents: and even when interrogating oneself, one pushes the



KEPLER'S HELIOCENTRIC UNIVERSE

Kepler sought to find the principle behind the organization of the solar system. In his Mysterium Cosmographicum, *published in 1596, he shows the distances between the planetary orbits by inscribing them in ordered Platonic solids. The outermost sphere represents the orbit of Saturn; inside it is a cube separating the orbits of Saturn and Jupiter; next is a tetrahedron, separating the orbits of Jupiter and Mars; then a dodecahedron, icosahedron, and octahedron separate the orbit of Mars from those of Earth, Venus, and Mercury, respectively. Thus, each of the Platonic solids is used. At the center is the Sun.*

Earth (or in old German *Herthum)* and Aristarchus said, that the Earth does not stand still as the Hearth does, and that it was also not the center of the universe, as the Hearth is at the center of the house, he had thus displaced the goddess from her Hearth, and thus committed blasphemy. On account of this fear, and on account of the reputation of Aristotle, who rejected this teaching (although he did not yet fully understand it), this teaching was suppressed, and particularly because it was difficult to understand, it was nearly forgotten over the time of 1,800 years; and finally there were no more Pythagorean philosophers, among whom alone this teaching was to be found. In particular, this teaching was significantly altered after Pythagoras, for after the birth of Christ, the Platonics also took it up. But they did not rely upon the mere tradition of the ancients; rather, when they could not get into their heads the grounds for a Pythagorean conception, they simply left it out, which is presumably what happened with this point of the teaching about the movement of the Earth.

5 For fire, understand the Sun, as above, and you will then see sufficient reasons for this. The Sun is more beautiful than the Earth, the Earth is dark and cold, imparts nothing to the Sun; the Sun, however, shines upon and warms the Earth, makes it full of life, indeed carries it around in the universe with its rays of light, just as a river carries a boat along with it. For the Sun indeed stays in its position, but revolves, and we see every day, with and without a telescope, that the black spots in the Sun shift along the path which the Earth and all the Planets must run, and quicker than the quickest; thus it is obvious, that all planets follow the rays of light moving ahead (thus leaping forth out of the revolving Sun, and turning with it) but never reach its velocity, the farthest, Saturn, the least, the closest, Mercury, the most. Thus if one perceives a hollow disk, or instead only a circle drawn upon a surface, this is an image of the Holy Trinity, the Center signifies God the Father,

inquiry only to the point at which one can no longer offer any opposition. Hence a good inquirer will be one who is ready in bringing forward the objections proper to the genus, and that he will be when he has gained an understanding of all the differences.

Anaximines and Anaxagoras and Democritus give the flatness of the Earth as the cause of its staying still. Thus, they say, it does not cut, but covers like a lid the air beneath it. This seems to be the way of flat-shaped bodies: for even the wind can scarcely move them because of their power of resistance. The same immobility, they say, is produced by the flatness of the surface which the Earth presents to the air which underlies it; while the air, not having room enough to change its place because it is underneath the Earth, stays there in a mass, like the water in the case of a water-clock. And they adduce an amount of evidence to prove that air, when cut off and at rest, can bear a considerable weight.**[15]**

Now, first, if the shape of the Earth is not flat, its flatness can not be the cause of its immobility. But in their own account, it is rather the size of the Earth than its flatness that causes it to remain at rest. For the reason is that the air is so closely confined, that it can not find a passage, and therefore stays where it is, because of its great amount;**[16]** and this amount is great, because the body which isolates it, the Earth, is very large. This result, then, will follow, even if the Earth is spherical, so long as it retains its size. So far as their arguments go, the Earth will still be at rest.**[17]**

In general, our quarrel with those who speak of movement in this way, can not be confined to the parts: it concerns the whole universe. One must decide at the outset whether bodies have a natural movement or not, whether there is no natural, but only constrained movement. Seeing, however, that we have already decided this matter to the best of our ability, we are entitled to treat our results as representing fact. Bodies, we say, which have no natural movement, have no constrained movement; and where there is no natural and no constrained movement, there will be no movement at all. This is a conclusion, the necessity of which we have already decided, and

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the outer circle God the Son, and what is between them, the space which is the same around and same divergence of the circle from the Center, is God the Holy Spirit, for, as no man may deny without denying the one Divine being, challenge what you will about the circle, either that it has no middle point or center, or that it has no circumference, or that there is no equality of curvature of the circumference from the center, thus have you foolishly contradicted the entire circle, and all three features together. As we allow of an order among the persons, that the Father is the First, the Son being the other person, for that reason that the Father is the Beginning and both, Father and Son, send the Holy Spirit; thus is there also order in the circle, the center is the first and the beginning, the circle is what is created, and between the two of them, one measures first the curvature, whether it is everywhere the same; and when the point remains a point, then it is no circle, but as soon as it spreads out and becomes a circle, then the circle circumscribes a space between the center and the circumference. That is why the Pythagoreans justifiably thought, but in their own language, that the center is of greater dignity than that space which is in between it and the circumference. Since also the Sun is the chief feature of the entire universe, as far as the spheres are concerned, indeed the heart, and the seat in which the life of the universe naturally shines, and the light that is the decoration of the universe, it deserves the central position, not for the reasons that the Pythagoreans thought, that it is protected, but because it sends out its light unchangeably and without any excess over time for the others uniformly in the entire universe. And it stands to reason, that the Pythagoreans call this element of the universe, when it is at its central position, Jupiter's guard, for Jupiter had received the name of life, *pseus,* of beginning, *gea,* and of light, *phaethon,* for the reason that they did not mean fire as that which consumes externally, but the Sun as a living creating fire, and the innermost or the beginning of all natural forces.

6 That in a living body the heart is not exactly in the middle, that is the reason for its needing feet to move and other such things, which the universe does not need: thus no reason can be conceived for the heart of the universe being anywhere else, than in the center. But that is a problem for Aristotle, for he thinks that one can see with one's eyes, that the Earth is in the center, so that what the Pythagoreans say is the heart of the world (which can not be the Earth) must be outside of the center point. But he is mistaken, because he had not a sufficient account of optics.

What Aristotle says here, thus sounds as if he wanted to explain to the Pythagoreans, that they should not attribute to the element of fire, and thus also not to bodily form, that which belongs to God, for God were the heart or centerpiece of the universe. Now, no one denies, that the Beginning is from God: But, as in a living being (this is also what Aristotle wants us to conclude), in addition to the soul there is also a member that was consecrated to the soul from the beginning, and would otherwise be useful for no work, namely the heart. Thus one would not deny that the Sun also is such an instrument of God, and therefore He would have to accord it its fitting place.

7 Aristotle uses the word center quite differently than the Pythagoreans; they do not say that the Sun occupies the entire space circumscribed by the outer stellar sphere, or even a large part of it; they mean the innermost point, which is truly the beginning of the circle, which does not require a boundary, but creates and forms the circumference. And in comparison with divine things, I do not take the space between the center and the circumference as an image of the third person, but solely the uniformity of the divergence of such a circumference from the center. Let it be conceded to Aristotle, that in the circle the circumference has greater dignity than the inner space; the reasons he cites, however, which are taken from bodily things, I do want to contest, for although there is more art in the fence than in the garden, more in the barrel than the water, more in the cup than the juice it contains, yet the fence

we have seen further, that rest also will be inconceivable, since rest, like movement, is either natural or constrained. But if there is any natural movement, constraint will not be the sole principle of motion or of rest. If, then, it is by constraint, that the Earth now keeps its place, the so-called "whirling" movement by which its parts came together at the center, was also constrained. (The form of causation supposed they all borrow from observations of liquids and of air, in which the larger and the heavier bodies always move to the center of the whirl. This is thought by all those who try to generate the heavens to explain why the Earth came together at the center. They then seek a reason for its staying there; and some say, in the manner explained, that the reason is its size and flatness, others, with Empedocles, that the motion of the heavens, moving about it at a higher speed, prevents movement of the Earth, as the water in a cup, when the cup is given a circular motion, though it is often underneath the bronze, is for this same reason prevented from moving with the downward movement which is natural to it.) But suppose both the "whirl" and its flatness (the air beneath being withdrawn) cease to prevent the Earth's motion, where will the Earth move to then? Its movement to the center was constrained, and its rest at the center is due to constraint; but there must be some motion which is natural to it. Will this be upward motion or downward, or what? It must have some motion; and if upward and downward motion are alike to it, and the air above the Earth does not prevent upward movement, then no more could air below it prevent downward movement. For the same cause must necessarily have the same effect on the same thing.

Further, against Empedocles, there is another point which might be made. When the elements were separated off by Hate, what caused the Earth to keep its place? Surely the "whirl" can not have been then also the cause. It is absurd, too, not to perceive that, while the whirling movement may have been responsible for the original coming together of the parts of Earth at the center, the question remains, why *now* do all heavy bodies move to the Earth? For the whirl surely does not come near us. Why, again, does fire move upward? Not,

exists for the sake of the garden, the barrel for the sake of the water, and the cup for the sake of the juice.

8 This is true, the Earth together with the Moon revolve around the Sun once each year.

It can happen that, for example, a comet appears, one so large, and so close to the Moon, and so dark, that it casts shadows upon the Moon, and even deprives it of the light of the Sun. Even if this does not happen, there are reasons why lunar eclipses are more numerous than the solar, so we do not require any special reasons to explain this.

9 Let it suffice to say, as large as one generally makes the outer stellar sphere with respect to the diameter of the Earth, they make it just as large with respect to the entire circumference in which the Earth revolves around the Sun. According to Archimedes, Aristarchus made it larger still, as the center is to the circumference, so is the entire circumference of the orbits of the Earth with respect to the highest hollow sphere of the fixed stars.

10 They mean, that one sees the Sun over the surface of the Earth, as if over a long round wave.

11 Indeed, if we stood far away from the Earth, and the Earth seemed as large as, but not much larger than the Sun, this section would have to be round, or if it were straight, the Earth would also have to be straight along the same latitude.

12 The Earth attracts it the way a magnet attracts iron.

13 To the contrary, there is nothing else that the Earth attracts to itself.

14 Completely wrong; they would fall to the Earth, and on the same side, but if the Earth were too far away, they would remain suspended or fall together.

15 If the air had only an open pin-hole, it would gradually shoot to the outside through this hole if it were pressed by such a weight.

16 Aristotle ridicules them because they did not think that air is in open space all around the Earth, not permitting itself to be trapped beneath the Earth.

17 The conclusion here would be somewhat different, and I base my argument on it. It is true, if a thing has no path of its own before it that it strives to travel, and when it has no inherent tendency to remain at rest in one place where it is put, it can still not be said that violence is done to it from the outside when it is transported and moved. But all corporeal things and the matter of all things in the whole world are of this kind, or rather of this dead passivity, that they are dumb and incapable of moving themselves from one place to the other, and must therefore live off of another, or be pulled from the outside and pushed, as will be shown in greater detail below.

18 The Earth attracts such things as a magnet attracts iron. Heavier air displaces the lighter fire, as water displaces bubbles which have to float above it, and this occurs according to the weight, so that what Aristotle wants to argue does not follow, that the Earth would have to have a particular place toward which it strives.

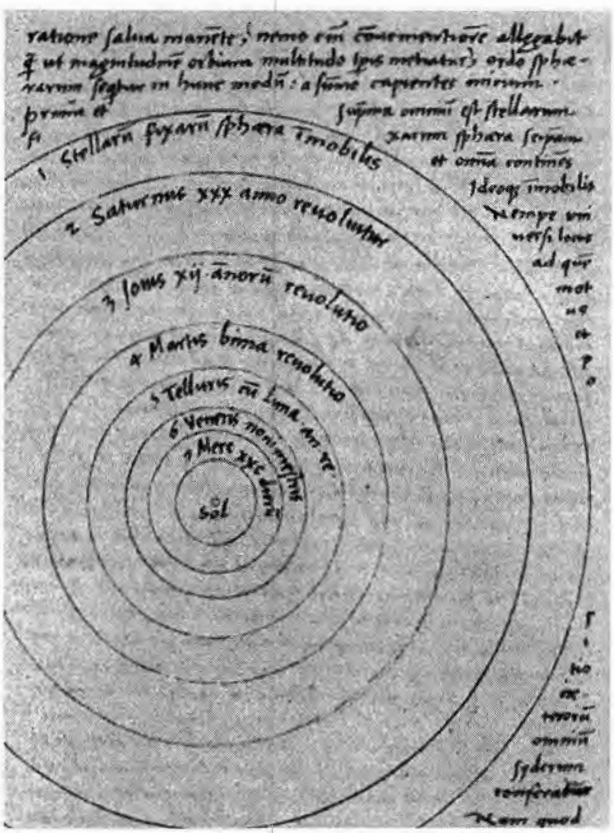
19 I distinguish light and heavy quite differently. Heavy is that which has much Earthly material of a certain density, but light is that which has either none, or only little of this, for example, fire, heat, and so on. And this includes the fact that both are close enough to the surface of the Earth, that they are gripped by its magnetic attraction.

surely, because of the whirl. But if fire is naturally such as to move in a certain direction, clearly the same way may be supposed to hold of Earth.**[18]** Again, it can not be the whirl which determines the heavy and the light. Rather, that movement caused the pre-existent heavy and light things to go to the middle and stay on the surface respectively. Thus, before ever the whirl began, heavy and light existed; and what can have been the ground of their distinction, or the manner and direction of their natural movements? In the infinite chaos, there can have been neither above nor below, and it is by these that heavy and light are determined.**[19]**

It is to these causes that most writers pay attention: but there are some, Anaximander, for instance, among the ancients, who say, that the Earth keeps its place because of its indifference. Motion upward and downward and sideways were all, they thought, equally inappropriate to that which is set at the center and indifferently related to every extreme point; and to move in contrary directions at the same time was impossible; so it must needs remain still. This view is ingenious but not true. The argument would prove, that everything, whatever it be, which is put at the center, must stay there. Fire, then, will rest at the center**[20]:** for the proof turns on no particular property of Earth. But this does not follow. The observed facts about Earth are not only, that it remains at the center, but also, that it moves to the center. The place to which any fragment of Earth moves, must necessarily be the place to which the whole moves;**[21]** and in the place to which a thing naturally moves, it will naturally rest. The reason then is not in the fact that the Earth is indifferently related to every extreme point: for this would apply to any body, whereas movement to the center is peculiar to Earth. Again, it is absurd to look for a reason why the Earth remains at the center and not for a reason why fire remains at the extremity. If the extremity is the natural place of fire, clearly Earth must also have a natural place.**[22]** But suppose that the center is not its place, and that the reason of its remaining there is this necessity of indifference--on the analogy of the hair which, it is said, however great the tension, will not break under it, if it be evenly distributed, or of the man who, though exceedingly hungry and thirsty, and both equally, yet being equidistant from food and drink, is therefore bound to stay where he is—even so, it still remains to explain why fire stays at the extremities. It is strange, too, to ask about

20 In my opinion, this is easy to solve: I also claim in the same way, not only of the center, but of any position, that that which is placed in it is a dead body if it is not drawn by something outside of itself; it will not move of its own, just for the very reason that it is dead, or is inert and has no tendency of its own.

21 The issue here is Aristotle's own opinion: but he makes a fundamental mistake when he thinks, that we see that the Earth is truly in the center and that it strives to that place. We do not see this at all. We do, indeed, see that the Earth could not be far away from the center of the heaven on account of the immeasurably great breadth of the heaven. But it does not follow from that, that the Earth is actually at the center. Here our eyes see far too little to be able to distinguish how far away we truly are from that place of the starry heaven. It is merely something we believe, each of us, that he is the center of the world, and the only difference between what we believe and what Aristotle believes is some 800 miles, at least. If we can make such a mistake, he can make a much greater one, 1,200 times more. Moreover, the theory of Aristotle is also not correct, when he says that where a piece falls, to that place the whole will also fall if it were in the same place. Indeed, if it were certain that such a piece desired to be at a particular position, and on its own account, and not because the whole desired it. But that is not demonstrated here. For we readily see that a piece of Earth will fall upon the whole Earth. But whether it falls



COPERNICUS' WORLD SYSTEM

Kepler praised Copernicus (1473-1543) for having freshly reconceived the necessity of the heliocentric system—for which the heliocentric ideas of the ancients, in themselves, are no substitute. Yet Copernicus' system was largely a geometrical rearrangement to make the system work, not a truly scientific investigation. For Copernicus and Galileo, for example, it was unthinkable that planetary orbits might not be circular. Here, a detail from Copernicus' first work, the Commentariolus *(Little Commentary), written before 1514 and circulated in a few manuscript copies.*

Source: Rossmann, ed., 1948

things staying still but not about their motion—why, I mean, one thing, if nothing stops it, moves up, and another thing to the center.**[23]** Again, their statements are not true. It happens, indeed, to be the case, that a thing to which movement this way and that is equally inappropriate, is obliged to remain at the center. But, so far as their argument goes, instead of remaining there, it will move, only not as a mass, but in fragments.**[24]** For the argument applies equally to fire. Fire, if set at the center, should stay there, like Earth, since it will be indifferently related to every point on the extremity. Nevertheless it will move, as, in fact, it always does move when nothing stops it, away from the center to the extremity. It will not, however, move in a mass to a single point on the circumference—the only possible result on the lines of the indifference theory—but rather each corresponding portion of fire to the corresponding parts of the extremity, each fourth part, for instance, to a fourth part of the circumference. For since no body is a point, it will have parts. The expansion, when the body increased the place occupied, would be on the same principle as the contraction, in which the place was diminished. Thus, for all the indifference theory shows to the contrary, Earth would also have moved in this manner away from the center, unless the center had been its natural place.**[25]**

We have now outlined the views held as to the shape, position, and rest or movement of the Earth.

Chapter 14 (296a24 ff.)

Let us first decide the question whether the Earth moves or is at rest. For, as we said, there are some who make it one of the stars, and others who, setting it at the center, suppose it to be "rolled" and in motion about the pole as axis. That both views are untenable will be clear if we take as our starting point the fact that the Earth's motion, whether the Earth be at the center or away from it, must needs be a constrained motion. It can not be the movement of the Earth itself. If it were, any portion of it would have this movement; but in fact every part moves in a straight line to the center. Being, then, constrained and unnatural, the movement could not be eternal. But the order of the universe is eternal.**[26]** Again, everything that moves with the circular movement, except the first sphere, is observed to be passed, and to move with more than one motion. The Earth, then, also, whether it move about the center or is stationary at

because of the presence of the whole, or because of the position in which the whole is placed, is still in doubt among the parties. But beyond this dispute, my view is correct that a weight will fall upon the ground beneath it on account of the ground and the Earth itself, and not on account of the position of the Earth.

22 What he intends to say is, that if one attributes to each creature of nature that a particular position is appropriate to this creature, a position toward which it strives, and that it should remain at that position once it has reached it, then one ought to be able to draw further conclusions in that way concerning fire and Earth and all creatures. But if one give as the reason why the Earth remains in its position, that it is equally distant from all other positions, then this has nothing in particular to do with the Earth, because one might say that of any creature, since not every creature remains in such a position as is equally distant from all others. As an example, according to Aristotle, fire has its own appropriate position, that is, at that point of the outer circumference from which there is a much greater distance to the opposing end of the circumference than to the next segment of the circumference adjacent to it. But according to Aristotle, those scientists did not think of this, who also say the same thing about fire, but only argued this ridiculous excuse on account of the Earth remaining still.

Now, I am as little satisfied with Aristotle, when he thinks it is sufficient to have asked why the Earth remains at the center of the world, and to answer, that nature assigned this position to it. For it is entirely uncertain, and not conceded by me, that the Earth is in the middle of the world; and were it so, it would be so indeed on account of nature, but in the same way that all things are on account of nature. But since one is not satisfied to know that things are according to nature, but one asks why they are that way and not some other way, and what means nature used to bring this about.

23 Beneath and in the middle of the whole world are to him places where a thing may be, but not to me. A thing may be beneath and in the middle of the Earth, but this has nothing to do with the center of the entire universe.

24 The center is only a point, but creatures are endowed with body, which occupies a space. On that account alone, it is, of course, true that no thing can be at the center, or at a point, but it distributes all parts of its body around such a point, and all of its parts are outside the center, some closer, some nearer than the others. Therefore the presumed reason why the parts would remain still, does not exist.

25 For a scientist it is not at all sufficient that Aristotle argues here, with mere words, that the Earth remains at the center of the universe for the sole reason, that its nature strives toward that position; rather, I would also like to know why that is so, by what means the Earth or its nature could find and reach this place. And then, how can the Earth, or its nature, notice, know, and seek the center of the universe, which is only a point—and then move itself to that position? The Earth is no hawk and the center of the universe is no little bird, it is also not a magnet which draws the Earth to itself, for it has no body, and thus has no such force. The Earth being itself a very large body, it would draw all other bodily creatures toward itself with a magnetic force, but some more than others, water more than air, and air more than fire, from which it would follow that, since water, air and fire are fluid things, which avoid each other and distribute themselves everywhere, that fire would let the air flow beneath it or be pulled above it, and air would allow itself to be driven over itself by water, which wants to be beneath. These are all things which the Earth does, with its magnetic attraction. But a single point, which has no body, and is also no quantity, such a thing can

it, must necessarily move with two motions. But if this were so, there would have to be passings and turnings of the fixed stars. Yet no such thing is observed. The same stars always rise and set in the same parts of the Earth.**[27]**

Further, the natural movement of the Earth, part and whole alike, is to the center of the whole—whence the fact that it is now actually situated at the center—but it might be questioned, since both centers are the same, which center it is toward which portions of Earth and other heavy things move. Is this their goal because it is the center of the Earth, or because it is the center of the whole? The goal, surely, must be the center of the whole. For fire and other light things move to the extremity of the area which contains the center. It happens, however, that the center of the Earth and of the whole, is the same. Thus they do move to the center of the Earth, but accidentally, in virtue of the fact, that the Earth's center lies at the center of the whole.**[28]** That the center of the Earth is the goal of their movement, is indicated by the fact, that heavy bodies moving towards the Earth do not move parallel but so as to make equal angles, and thus to a single center, that of the Earth. It is clear, then, that the Earth must be at the center and immovable, not only for the reasons already given, but also because heavy bodies forcibly thrown quite straight upward, return to the point from which they started,**[29]** even if they are thrown to an infinite distance. From these considerations, then, it is clear, that the Earth does not move and does not lie elsewhere than at the center.

From what we have said, the explanation of the Earth's immobility is also apparent. If it is the nature of Earth, as observation shows, to move from any point to the center, as of fire contrariwise to move from the center to the extremity, it is impossible, that any portion of Earth should move away from the center except by constraint. For a single thing has a single movement, and a simple thing a simple: contrary movements can not belong to the same thing, and movement away from the center is the contrary of movement to it. If, then, no portion of Earth can move away from the center, obviously still less can the Earth as a whole so move. For it is the nature of the whole to move to the point to which the part naturally moves. Since, then, it would require a force greater than itself to move it, it must needs stay at the center.**[30]** This view is further supported by the contributions of mathematicians to astronomy, since the observations made as the shapes change by which the order of the stars is determined, are fully accounted for on the hypothesis, that the Earth lies at the center. Of the position of the Earth, and of the manner of its rest

not do these things. For these reasons, and—were I of the opinion that the Earth remains still—I would want to explain this by saying that it remains in the center of the universe because it was put there from the beginning, but that it had no living and moving power to be able to move itself from that place where it was put, and there would be nothing outside of it which could move it from this place, or to another place. Against this argument Aristotle has still said nothing. For I am not of the opinion, that the Earth stands still, but rather am certain of the view held by astronomy, that it not only itself revolves, which revolutions take each one day, but also changes its position and continuously moves in a large orbit among the other planets, and each of these revolutions takes one year: So in light of what was said before about its standing still, it further possesses something spiritual, like a soul in a body, by means of which force it rotates, and there is also a magnetic force necessary, by means of which it is moved in its orbit, which force is rooted in the very large body of the Sun, from which it flows out into the universe and takes hold of all the planets, and, as it reaches each one, drives it around in its orbit, in which path the Sun itself, being its source, rotates.

26 These two views are held nowadays by all properly grounded astronomers, except that it does not rotate in the middle of the universe, as the Sun does, but in its orbit or its own heaven, and moves forward, almost like a ball which one pushes toward the bowling pins. To this I therefore answer, the rotation is caused by an inner reason, but that the Earth also moves forward has its reason outside, that is, from the magnetic force of the Sun. Although the rotation has an inner reason, this reason is not laid into the stuff or the material, such that each part is of such material, so that every piece of Earth would have to have this nature in it, but rather as the moving power of the soul lies in each person's body, it does not follow, that every piece of fingernail, ear, nose, finger, or hand must also so move as the whole body moves on account of the power of its soul; this is also the situation with the Earth as a whole and its moving force, and with the Earthly creatures, stone, wood, and the like. Now as concerns this movement, coming from the inner force of the Earth, indeed it really struggles to move against its inertia and overcomes it, as was said above, so there is no reason to think it as an unnatural compulsion. The heart is also loath to move, as far as its flesh is concerned, but the living force which is in it moves and makes this fleshy part beat incessantly, so that it pumps 100,000 times each day, and that over 60 or 70 or 80 years, so that within a human being over his lifespan, the heart beats 1,000 times more than the Earth revolves in 6,000 years. When a boy spins a top, how many times does it spin around before it falls over, since then the movement enters from the outside, and the moving force has to fight mightily not alone with the inertia of the wood of the top, but also with its weight, which pulls the top down, against which the motion must maintain it upright, likewise with the unevenness of the rough ground upon which the point always strikes and catches, and necessarily encounters friction. Why then would not the inner force of the Earth become so great, that it be the sole reason for this rotation, overcoming inertia so completely, to a certain extent as a consequence of the velocity of the rotation, and why would not such a moving force become implanted in the Earth, remaining in it both eternally and unceasingly, and having effect as if the matter or the Earth were eternal and indestructible? If our body were indestructible, the soul is so constituted, that it would never leave the body, for the soul is immortal.

or movement, our discussion may here end.**[31]**

Its shape must necessarily be spherical. For every portion of Earth has weight until it reaches the center, and the jostling of parts greater and smaller would bring about not a waved surface, but rather compression and convergence of part and part until the center is reached. The process should be conceived by supposing the Earth to come into being in the way that some of the natural philosophers describe. Only they attribute the downward movement to constraint, and it is better to keep to the truth and say, that the reason of this motion is, that a thing which possesses weight, is naturally endowed with a centripetal movement.**[32]** When the mixture, then, was merely potential, the things that were separated off, moved similarly from every side toward the center. Whether the parts which came together at the center were distributed at the extremities evenly, or in some other way, makes no difference. If, on the one hand, there were a similar movement from each quarter of the extremity to the single center, it is obvious, that the resulting mass would be similar on every side. For if an equal amount is added on every side, the extremity of the mass will be everywhere equidistant from its center, that is, the figure will be spherical. But neither will it in any way affect the argument if there is not a similar accession of concurrent fragments from every side. For the greater quantity, finding a lesser in front of it, must necessarily drive it on, both having an impulse whose goal is the center and the greater weight driving the lesser forward till this goal is reached. In this we have also the solution of a possible difficulty. The Earth, it might be argued, is at the center and spherical in shape; if, then, a weight many times that of the Earth were added to one hemisphere, the center of the Earth and of the whole will no longer be coincident. So that either the Earth will not stay still at the center, or if it does, it will be at rest without having its center at the place to which it is still its nature to move. Such is the difficulty.**[33]** A short consideration will give us an easy answer, if we first give precision to our postulate, that any body endowed with weight, of whatever size, moves towards the center. Clearly, it will not stop when its edge touches the center. The greater quantity must prevail until the body's center occupies the center. For that is the goal of its impulse. Now, it makes no difference whether we apply this to a clod or common fragment of Earth or to the Earth as a whole. The fact indicated, does not depend upon degrees of size, but applies universally to everything that has the centripetal impulse. Therefore, Earth in motion, whether in a mass or in fragments, necessarily continues to move until

27 Answer: we astronomers prove, that the fixed stars, one way or the other in human conceptions, must always rise at one place on the Earth, whether the Earth stands still or rotates on its axis and orbits around the Sun. And it seems, moreover, that Aristotle did not study his astronomy very well, as in our times Joseph Scaliger has also lost himself in it. First of all, it does not follow, that because this star is passed, it must have two movements. For this only holds in reckoning by the Sun, which would also be thought of as if it went from setting to rising. Second, we astronomers demonstrate, that such planets as are passed do not have two movements, but that the orbit in which one does not, in our opinion, follow the other, is only an apparent movement, and it seems that way, because the Earth moves around with us, whereas we think that the stars, in addition to their own orbits, also move in the orbit of the Earth. Thus we have good reason to turn Aristotle's own argument against him, since: if the Earth revolved, one would have to assume, that all stars which truly have only one orbit, would seem as if they had many orbits, and one of them would always remain behind. But this is exactly what happens, and therefore the Earth has one orbit. Third, it does not follow that, if all other planets are passed, that this must also be the case with the Earth as well. For if they had their own orbits from their rising toward their setting, they would always be running ahead, and would also leave the fixed stars behind them. It follows much less, that if the Earth had two orbits, the stars would therefore set for awhile toward Hungary, then for awhile toward Spain; for when astronomers say that a star, or even the Earth, has two orbits, they do not mean by that two orbits such that one revolves around the other, the one for itself, and the other behind it; instead they mean two orbits, such that the one does not preclude the other, but both move in continuous, uninterrupted motion, mixed together.

28 Answer: Here everything depends upon whether the stone falls toward the center of the universe or to the middle of the Earth. I say, that it does not fall to the middle of the universe, but to the center of the Earth. One sees the reason for this: The Earth draws such heavy things toward it the way a magnet draws the iron, and there is no evident reason why the Earth should be interested in a little point, which has neither body nor force.

But what Aristotle cites as proof about fire, this is not tenable: Fire does not desire to move upward into the heavens; rather it flees all closeness, for it must have room, and expands all moist things; besides, it flees air, which is much heavier than it is. And once it gets out where there is room, there it remains, and goes no farther. But it is still undecided whether fire moves from the center points of all [particular] things in a straight line outward toward the most distant point, or whether its flight is directed toward the center of all things: If, on the one hand, it aims precisely at the center [of all things], this happens only accidentally, for, on the other hand, its flight is then going straight for the center point while the Earth is outside this center.

29 That all things fall in the direction below themselves from where they are thrown, is the result of the attractive force of the Earth, and this is not in the center, but in the entire body, and those parts of the Earth pull most strongly, which are closest to the stone which is thrown: it thus pulls them in flight around with itself, for it pulls them toward itself by the shortest path.

30 For a thing to stand still or remain where it is, it is not necessary, that the thing be so constituted as to move to

it occupies the center equally every way, the less being forced to equalize itself by the greater owing to the forward drive of the impulse.

If the Earth was generated, then, it must have been formed in this way,**[34]** and so clearly its generation was spherical; and if it is ungenerated and has remained so always, its character must be that which the initial generation, if it had occurred, would have given it. But the spherical shape, necessitated by this argument, follows also from the fact, that the motions of heavenly bodies always make equal angles, and are not parallel. This would be the natural form of movement towards what is naturally spherical. And it is right to call anything by a name denoting what nature intends it to be, and which belongs to it, rather than that which it is by constraint and contrary to nature. The evidence of the senses further corroborates this. How else would eclipses of the Moon show segments shaped as we see them? As it is, the shapes which the Moon itself each month shows are of every kind—straight, gibbous, and concave—but in eclipses the outline is always curved: and, since it is the interposition of the Earth that makes the eclipse, the form of this line will be caused by the form of the Earth's surface, which is therefore spherical. Again, our observations of the stars make it evident, not only that the Earth is circular, but also that it is a circle of no great size. For quite a small change of position to south or north causes a manifest alteration of the horizon. There is much change, I mean, in the stars which are overhead, and the stars seen are different, as one moves northward or southward. Indeed, there are some stars seen in Egypt and in the neighborhood of Cyprus, which are not seen in the northerly regions; and stars, which in the north are never beyond the range of observation, in those regions rise and set. All of which goes to show not only, that the Earth is circular in shape, but also that it is a sphere of no great size: for otherwise the effect of so slight a change of place would not be so quickly apparent. Hence one should not be too sure of the incredibility of the view of those who conceive, that there is continuity between the parts about the pillars of Hercules, and the parts about India, and that in this way the ocean is one. As further evidence in favor of this, they quote the case of elephants, a species occurring in each of these extreme regions, suggesting that the common characteristic of these extremes is explained by their continuity. Also, those mathematicians who try to calculate the size of the Earth's circumference, arrive at the figure 400,000 stades.**[35]** This indicates not only that the Earth's mass is spherical in shape, but also that as compared with the stars, it is not of great size.

the place where it stands still; it is sufficient that it is not fit to move by itself; if a thing exists, and also has nothing to move it, it will remain in the place where it is put. And the Earth would have remained where it was put, unless there were something which moves it.

31 This does not follow: It is possible to explain the first part of astronomy, concerning day and night, summer and winter, the rising and setting of the stars, by such a heaven in which the Earth is at the center, and thus at the center of the universe. It is possible to explain all of this and still more, however, if the Earth revolves outside the center of the universe, and furthermore, one can not explain the second part of astronomy, concerning the particular orbits of the planets, as well and as perfectly, if the assumption is made, that the Earth stands still, instead of assuming, that it makes its yearly revolution around the Sun, but, thirdly, the reason why it is so easy for people to understand the first part of astronomy if the Earth is assumed to stand still, is that our face is on the surface of the Earth. Anyone must concede that, if we were on the Moon, we would just as soon believe, that the Moon stands still, and we would then develop astronomy in another way.

32 Aristotle claims to prove that the Earth is round, because he assumes it is at the center of the universe, so that all heavy things have fallen toward it. But I can make much better use of his own argument if the Earth is not at the center of the universe, and if heavy materials did not fall toward it. I do that in the following way: weight is nothing but the magnetic attraction of the Earth. Now, assume that the Earth is a soft, fluid heap; it would shrink together into a sphere, just as water droplets and mercury become spherical. For the more mass there is, it pulls the lesser toward it, which is further distant, and it does this again and again until it becomes a sphere.

Were the Earth a soft fluid when it was young, it would have taken on a round shape all of its own. But had it been created hard, its Constructor would have had to cut off its edges all around, but if He had wanted it to be round from the start, He would have used water, and would not have let it be dry and full of edges and without water. So He would rather have had it round from the start.

33 I deal with the question with the example of two unequal magnets: Let them be put into two small boats and let them swim around in a large vessel. They will move towards each other, the stronger moving less, the weaker more. But if one puts them together from the start, neither of them will push the other from its position. We can speak thus of two Earths, because each of them in itself (beyond its moving power or soul) is a dead heap, which can not move itself, but alone only has the attraction of magnetic force. If one then places two Earths next to each other, neither would move from the position in which it was put. The reason is, that they do not seek the place, as Aristotle would have it, but only the [other] body. It would indeed happen that everything free to move on the smaller one, would fall upon the larger one, and thus the smaller one would surely be denuded on one side.

34 Notice that Aristotle is so strongly convinced, that there was a beginning to the world, that he then adds to the [idea of the possible] eternity of the world, that it is still formed as if it had a beginning. Thus the one that provides form is more noble than another that does not have its form in itself.

35 That would be 10,000 miles, counting 40 stadia for one mile; that is surely about one-half too large.

AFTERWORD

The Context of Kepler's Attack on Aristotle's Lie

by George Gregory

When Aristarchus of Samos—Samos where Pythagoras was born—publicly propounded and demonstrated that our planetary system is heliocentric, that the planets revolve around the Sun, a follower of Aristotle, Kleanthes, denounced him before the religious court of Athens for committing blasphemy against the goddess Gaia, by "shifting her hearth" from its proper center. Johannes Kepler, in his refutation of Chapters 13 and 14 of Aristotle's *Peri Ouranou*, or *On the Heavens*—generally known under its Latin title *De Caelo*—points out that what Aristarchus proclaimed was known to the Pythagoreans much earlier, but that under the political-religious threat of the cult of Gaia, the Pythagoreans felt compelled to use a veiled language to describe their teaching. From Aristarchus onward, however, what the Pythagoreans said in veiled form, was perfectly clear.

Kepler insisted that Aristotle was to be held personally responsible for the fact that it was not until Copernicus, that the ancient Pythagorean knowledge could once again be understood. Kepler might have added, however, that Plato also knew what the Pythagoreans knew, but he also wrote in a manner usually thought to be veiled.

Kepler's detailed refutation of the sections of *Peri Ouranou* that he chose to translate, is sufficiently clear and entertaining to need hardly any commentary. The context, however, in which Kepler accused Aristotle of having sabotaged science for some 2,000 years, down to his own time, is worth a remark or two, particularly since it is on that issue that scholars have attempted to blunt Kepler's authority.

As the reader will notice, in point 4 of his refutation, Kepler claims that it was a *combination* of the *fear* of the Cult of Mother Earth (Gaia) and the *reputation* of Aristotle, which served to obfuscate ancient Pythagorean knowledge for so long. In making this point, which is objectively-historically accurate, Kepler, too, seems to have spoken "in a veiled way." He might as easily have said, that the "reputation" of Aristotle served the political-cult authority of the Cult of Gaia, and, indeed, that the "reputation" of Aristotle itself was feared. Aristotle's reputation was

The Vatican Museum

The centuries of conflict, between underlying Aristotelian and Platonic principles of knowledge, is recognized in The School of Athens, *by Raphael Sanzio, in which Aristotle and Plato are central, as seen in this detail. Kepler was firmly on the side of Plato. This mural, painted in 1510-1511, is one of several by Raphael in the Stanza della Segnatura in the Vatican.*

authoritative in Kepler's day, and there were political and religious reasons for the denunciation of Aristarchus. It was an act of considerable courage to say so.

Kepler wrote further in a veiled way. In a parenthetical remark, he graciously conceded that Aristotle might have been ignorant. Another possibility is that Aristotle was not ignorant, but chose not to write what his knowledge actually was. But was this *combination* of Aristotle's reputation and the interests of the Cult of Gaia merely a magical coincidence of history? If it was not a coincidence, then either Aristotle's possible ignorance was used and provided with the status of political-cult authority by the Cult of Gaia, or Aristotle was not ignorant at all, and he *knew* that he was conceding the authority of a political cult when he wrote *Peri Ouranou.* On that point, Aristotle may be fruitfully compared with Plato.

It is a most peculiar feature of *Peri Ouranou* that Aristotle nowhere attempts to explain the orbits of what the Greeks called the "wandering stars," that is, the planets (*planêtos* = wandering). Such a gaping hole in a work on astronomy is all the more astonishing, since the Athenian Stranger in Plato's dialogue, *The Laws,*[1] *does* speak about "one and eternal circular paths" of the planets (822a6-7, *mian aei kuklôi diexerchetai*).

Aristotle must have known *The Laws,* and he certainly knew corresponding, relevant passages in *The Republic.* So why does Aristotle say nothing at all about the movement of the planets?

The Athenian Stranger in *The Laws* (821a ff.) explains why Aristotle says nothing on this issue. He also hesitates (dramatically) to speak about it, because it is a religious issue, and also a political issue. "What I am trying to say, I know, is startling, and might be thought unbecoming in a man of our years, but the plain truth is that a man who knows of a study which he believes exalted, true, beneficial to the community, and perfectly acceptable to the god, simply cannot refrain from calling attention to it." The question is not only what is true about the planets, but also what the god likes to hear about such things, and whether it is useful for the city that the truth be said and also taught to the youth.

From the vantage point of the surface of the Earth, one looks up into the night sky and observes the planets moving every which way, as the Stranger's partner in discourse, Clinias, affirms (821c1). Not only do they manifest apparently chaotic movements when viewed from the surface of the Earth (movements which the later Ptolemaic epicycles attempted to resolve in good Aristotelian fashion, maintaining the Earth at the center), but, as the Athenian Stranger also points out (822b), the slower planet even seems to be the faster one.[2]

According to the popular Greek view, the planets were divinities. The Athenian Stranger has a more important assault on the Cult of Gaia in mind than challenging that belief, which we today think is just silliness. To attribute to these "divinities" the sorts of movements which we can observe from the surface of the Earth, says the Stranger, is "blasphemous" and cannot be pleasing to the gods at all: the planets really move in regular circular orbits, and the slower ones do not run past the faster ones. The "blasphemy" consists in the popular view, which attributes mindless movement to divinity, and so the Cult of Gaia, which insists that the center, that is, the standpoint from which to discover the movements of the planets, is the Earth, is itself "blasphemy." It stands to reason, likewise, that the city cannot expect youth to be reasonable or civilized if they are taught that the gods move around the heavens helter-skelter.

The Athenian Stranger does not *say* that to his partners in the discussion. He only implies the political accusation, particularly with his reticence to speak about it at all. The common view was that the "philosophers of nature" undermine the laws of the city and their sacred, divine basis, and so Socrates (according to Plato's *Apology*) claimed at his trial that his accusers had launched the accusations against him as if he were a "philosopher of nature," which he said he was not.

The reader will notice that point 2 of Kepler's objections to Aristotle deals with the relative speeds of the several planets. In Plato's *Laws,* the Stranger is not as explicit about the specific planets. But: in order to be able to say that the slower planets do not, in reality, move faster than and surpass the quicker ones, Plato's character, the Stranger, had to have known in principle exactly what Kepler says about the specific planets.

Not only did Plato write in a veiled way: he let his Stranger speak to his dialogue partners likewise in a veiled way. The Stranger does not tell his partners in the dialogue all that he knows, nor does he provide them any proof of what he does say. But that does not mean that the careful listener or reader needs to doubt whether the Stranger proves that he knows as much as Kepler knew. If he did not know it, he could not have said what he did say. The proof is sufficient.

Aristotle not only left out any mention of the relative speeds of the planets; he likewise claimed (see the opening of Chapter 13 in the translation of *Peri Ouranou* above) that the Pythagoreans, by placing "fire" (which Kepler interpreted to mean the Sun) at the center and letting the Earth and other planets move around that center, were merely theorizing against "observed facts," as if the Pythagoreans had had no reason to doubt that the testimony of "observed facts" was reasonable.

As one scholar recently put it, "Virtually everyone knows that Aristotle sometimes lies."[3] We do not know whether Aristotle lied in his representation of the teaching of the Pythagoreans, which is to say we do not know whether he knew that the Pythagoreans had good reasons to doubt the testimony of "observed facts," and Pythagorean sources are either nonexistent, second- or third-hand, or very thin. Today, we would say that Aristotle was a scientific empiricist, and it was that empiricism of his which became historically authoritative and "traditional" for science, although we still cannot decide whether Aristotle himself knew better.

Aristotle *could* have invented some Ptolemaic epicycles to infuse some order into the "mindless motion of divinities," but the epicycles could never have solved the problem of the relative velocities of the planets, as the Athenian Stranger in Plato's dialogue demands. And epicycles are not regular cir-

cular orbits.

Aristotle did nothing by way of acknowledging or attempting to solve the problem posed by the Athenian Stranger in the *Laws* dialogue. In his work devoted to astronomy, he neglected—or refused—to discuss the motion of the planets, except for one *lie* in Chapter 14, 297a5, ". . .the observations made, as the shapes change by which the order of the stars is determined, are fully accounted for on the hypothesis that the Earth lies at the center." Were the "observed facts" indeed fully accounted for by the geocentric hypothesis, the Stranger in Plato's *Laws* could never have posed the paradox of the apparent and real speed of the motions of the planets as he did, and Aristotle had to have known that.

Kepler answers this in point 31 of his critique: the orbits of the planets can not be accounted for from the standpoint of the Earth as the center of the planetary system, although day and night, and the seasons, can.

In this specific case, Aristotle *knew* that he lied. He also knew the program for astronomy, outlined by Socrates in Book VII of the Plato's *Republic*.[4]

In the *Republic,* Socrates set out the program (527d-530d) that astronomy must measure the invisible patterns of motion of the heavenly bodies. When Glaucon responded in astonishment, that this is a thing far greater than anything yet attempted in astronomy, Socrates replied that it must be done "if we are to be of any use as legislators." Thematically, therefore, both dialogues, the *Republic* and the *Laws,* agree that the study of astronomy is of the utmost political importance.

They also agree on a further point: when Socrates, in the *Republic,* characterizes astronomy as the study which follows solid geometry, in three dimensions, because (528d-e) "astronomy treats the motion of what has depth," he goes on to say (529d) that the study of astronomy which relies only on the observation of visible "observed facts," will fail to determine "those movements in which the *really* fast and the *really* slow. . . are moved with respect to one another and in their turn move what is contained in them."[5]

These and other such remarks have been understood traditionally to mean that physical reality, for Plato, does not perfectly correspond to a mathematical ideal. So the tradition places Aristotle on the side of empiricist sobriety and Plato on the side of inebriated idealism. The traditional reading, how-

AUS DEM ANDERN BUCH ARISTOTELIS VON DER OBEREN WELT
DAS DREYZEHEND CAPITEL

WAS DIE ALTE GEHALTEN VOM ORT DES ERDBODENS; OB ER STILLSTEHE ODER NIT, VND WAS ER FÜR EIN FORM HABE

Λοιπὸν δὲ περὶ τῆς γῆς εἰπεῖν, οὔτε τυγχάνει κειμένη, καὶ πότερον τῶν ἠρεμούντων ἐστὶν ἢ τῶν κινουμένων, καὶ περὶ τοῦ σχήματος αὐτῆς. περὶ μὲν οὖν τῆς θέσεως οὐ τὴν αὐτὴν ἅπαντες ἔχουσι δόξαν, ἀλλὰ τῶν πλείστων ἐπὶ τοῦ μέσου κεῖσθαι λεγόντων, ὅσοι τὸν ὅλον οὐρανὸν πεπερασμένον εἶναί φασιν, ἐναντίως οἱ περὶ τὴν Ἰταλίαν, καλούμενοι δὲ Πυθαγόρειοι λέγουσιν· ἐπὶ μὲν γὰρ τοῦ μέσου πῦρ εἶναί φασι, τὴν δὲ γῆν ἓν τῶν ἄστρων οὖσαν, κύκλῳ φερομένην περὶ τὸ μέσον νύκτα τε καὶ ἡμέραν ποιεῖν. ἔτι δ' ἐναντίαν ἄλλην ταύτῃ κατασκευάζουσι γῆν, ἣν ἀντίχθονα ὄνομα καλοῦσιν, οὐ πρὸς τὰ φαινόμενα τοὺς λόγους καὶ τὰς αἰτίας ζητοῦντες, ἀλλὰ πρός τινας λόγους καὶ δόξας αὐτῶν τὰ φαινόμενα προσέλκοντες καὶ πειρώμενοι συγκοσμεῖν. πολλοῖς δ' ἂν καὶ ἑτέροις συνδόξειε μὴ θεῖν τῇ γῇ τὴν τοῦ μέσου χώραν ἀποδιδόναι, τὸ πιστὸν οὐκ ἐκ τῶν

XIII. Noch ist yberig, das jch auch vom Erdboden schriebe wo derselbig sey, vnd ob er vnder die stillstehende oder vnder die vmbschwebende geschöpffe zu zehlen, auch von seiner form.

Was anlanget den Ortt des Erdbodens seind die gelehrte nit alle einerlay mainung dan obwol die maiste sagen, Er sey mitten in der Welt, jch maine die, so da den Himmel endlich vnd beschlossen fürgeben: so kehrens *1*
aber die in *Italia*, so man die *Pythagoricos* nennet, gerad vmb: dan Mitten in der Welt sagen sie, sey das feür, die Erd aber sey *2*
einer auß den vmbschwebenden Sternen, vnd werde vmb das Mittele ort der Welt in einem Krais herumb geführt, vnd also mache sie Tag vnd nacht. Yber das bauen sie noch ein *3*
andere Erde auff, vnd setzen sie diser vnserer bekanten Erden entgegen, geben jr auch den Namen, Ant-Erd. Befleissen sich also nit jre *4*
lehren nach dem offenbaren Augenschain zu stellen, oder desselbigen Augenschainsgründlichen Vrsachen nachzudenckhen: sondern zum Widerspil thunn sie, jre alte einbildungen vnd empfangne Lehren zu bestättigen, den offenbaren augenschain beim haar herzuezieheu, vnd vermainen dieselbige hiermit zu beschönen. Nu möchten sich auch vil andere mehr finden, die es mithalten vnd vermainen möchten, man soll der Erd nit das Mittele Ort der Welt einraumen: Wan sie jres glaubens vnd haltens gründe nit auff lauttern Augenschain stellen, sondern auch vnd vil mehr auff glehrte schlußreden: Dan also schließen sie, es sey billich, das dem Edelsten vnd

The opening of Kepler's translation of Aristotle in Rossmann's scholarly edition of 1948, which follows Kepler's orthography and punctuation. The Greek is a modern edition of Aristotle. The first points of Kepler's objections are keyed with numbers in the right margin.

Source: Rossman, ed., 1948

ever, will necessarily fail to make sense of the specification of astronomy as the study of solid geometry in motion, and it will leave aside entirely the summary remark (530b6 f.) that "By the use of problems, as in geometry, we shall also pursue astronomy."[6]

There is hardly a more explicit way to say that geometrical objects are not "models" or "ideals" in opposition to physical reality, but rather that it is by the study and solution of *problems* in geometry that the measurement of, for example, the real speed of planets, becomes possible. Measurement of the speeds of the planets on the basis of "observed facts" is not possible.

Kepler understood the methodological argument Socrates makes in the *Republic,* but he did not cite that argument.

It was also in the *Republic,* that Socrates revealed the truth about the Cult of Mother Earth. It is the source of the tyrannical and despotic Olympian law of the oligarchy. It is on behalf of the Mother Earth cult, that the oligarchy propagates the "Phoenician Lie," that human beings are "born of the Earth." Their souls are therefore "fixed," just as the ores of iron, silver, and gold are fixed. The laws of Sparta, which the Spartans claimed were divinely sanctioned by Apollo, were the ideal Mother Earth cult tyranny. And the word "Sparta" in Greek means "the men sown of the Earth." The Spartans, who pitted their laws against the laws of Solon, *self-consciously* represented their city and their political institutions as consecrated to the Cult of Mother Earth. In such a regime, the chief "virtue" is "to mind your own business," that is, not to challenge the oligarchy of the Olympians.

The Stranger's remarks on astronomy in Plato's *Laws* are tantamount to a "reform" of standard Greek "religious" beliefs. As the Stranger says (821d ff.),

> I am now insisting that our citizens and their young people must learn enough of all the facts about the divinities of the sky to prevent blasphemy of them, and to ensure a reverent piety in the language of all our sacrifices and prayers.

As Plato orchestrated the exchange, it was then the Cretan, Clinias, who replied, and not the Spartan, Megillus, whose agreement is manifest only in his failure to object openly:

> That is right, *provided, of course, that, in the first place, the knowledge of which you speak is possible.* On that assumption, *if* there are errors in our present teaching which study will correct, I, too, confess that a subject of such scope and quality must be taught.

In this exchange, the Athenian Stranger does not harvest the agreement of the Cretan to actually teach the new explanation. He only obtains Clinias' agreement to teach the new explanation (822c) "*if* we can show that [the facts] are so." The Greek belief that the "wandering stars" are divinities is useful, because neither Clinias nor Megillus is about to become a student of astronomy, but an agreement that "scientific research" may be the foundation, rather than the overthrow of a good regime, opens a breach in the possibilities for political manipulation of traditional belief. In his discussion with the Cretan and Spartan, the Athenian shows that we need not fear ignorance if we can obtain agreement that divinity is not irrational.

So, clearly, Aristotle was *not* ignorant, and Johannes Kepler knew that, of course. There is a delicious irony in Kepler's representation that Copernicus revived or rediscovered what the ancient Pythagoreans already knew, because Kepler himself revived Platonic science.

On Rossmann's Motives

The translation of Kepler's refutation of Aristotle printed here, is from the original, written by Kepler in 30-Years-War German, as published by Fritz Rossmann.[7] Rossmann also collected the various ancient sources and scholarly philological commentaries on them, with the aim of refuting Kepler's understanding of the Pythagoreans. In doing so, Rossmann's transparent intent is to concede Kepler's specific points of critique of Aristotle, while undermining the authority of Kepler's chief indictment: that Aristotle (or his authoritative reputation, as traditionally understood) sabotaged science for 2,000 years down to Kepler's own time. Apparently, Rossmann would like the reader to believe that the points of detailed critique are apolitical and "modern," but that the messy political issues, of which both Aristotle and Plato were aware, have nothing to do with "scientific debate." That was not true in Kepler's time, nor is it true today.

Once the messy political facts are recognized, it is clear that Johannes Kepler was accurate in his argument that the Pythagoreans spoke in a "veiled way." I present some of the sources which Rossmann collected, and also his sole piece of supposed evidence which he believes refutes Kepler, in order to let the reader decide whose authority stands and whose cannot stand.

First of all, Rossmann kindly cites from Copernicus' letter of transmission of his own work to Pope Paul III:[8]

> I thus undertook to investigate the works of all philosophers that I could obtain, in order to ascertain whether someone had entertained a hypothesis, that the movements of the heavenly bodies would have to be different from that assumed by school mathematicians. And so, of course, I first found a passage in Cicero, which says that Nicetas [actually Hicetas of Syracuse] had assumed that the Earth moves. I later also read in Plutarch that some others had also been of this view. I would like to write down here the literal words, so that everyone may be familiar with them: "The usual view, is that the Earth stands still. The Pythagorean Philolaus, however, hypothesizes that it moves in a circle around a central fire and that it describes a slanted circle in so moving, similar to the Sun and Moon. Heracleides Pontikos and the Pythagorean Ekphantos indeed have the Earth move, but it does not move from its position, but only such that it revolves like a wheel from West to East around its own center."

As Rossmann documents, the work Copernicus *thought* was authored by Plutarch, was actually the *De placitis Philosophorum,* proven by Hermann Diels to be a fragment of a work by Theophrastus. Theophrastus became a friend and student of Aristotle after Aristotle left the Academy of Plato when Plato died, and went to Assos in Asia Minor. When Aristotle subsequently left Asia Minor to go to the court of Philip in Macedonia, Theophrastus went with him from the island of Lesbos.

This serves to qualify Copernicus' source. Theophrastus may be termed Aristotle's "first student." His testimony singled out the Pythagorean Philolaus. Other Pythagoreans did not, according to Theophrastus, have the same view, but the view Theophrastus ascribes to Philolaus is fully coherent with Kepler's reading of what the ancient Pythagoreans knew. Had Kepler simply relied upon what Copernicus thought he was reporting from Plutarch, but actually from Theophrastus, he would not have gone wrong. The reader will notice that Kepler, in point 4 below, refers to the "Platonics" after the birth of Christ, who had lost the meaning of the Pythagorean teaching. In other words, the "Platonics" in the Christian era had lost the capacity to read Plato. That does not mean that Kepler himself had not read Plato.

Aristotle himself, and his student Theophrastus are, therefore, the most direct and immediate "sources" for the veiled heliocentric planetary system of the Pythagoreans. Theophrastus identifies the Pythagorean, Philolaus, specifically, and, in ancient times, that identification ultimately peaked in the claim of later Aristotelians that Plato himself had plagiarized the *Timaeus* dialogue from three books of Philolaus, which he had allegedly bought in Sicily.

The language of these "sources" is clear enough. The *only* source available, which Rossmann claims undermines Kepler's reading of the Pythagoreans, is Stobaios' *Eclogae Physicae:*

> Philolaus teaches that fire is in the middle and at the center-point, which he calls the "hearth of the universe" and "god-mother and -altar" and "connection and measure of nature." And he assumes a second fire which surrounds the universe. The first according to nature is the center; about this center do divine bodies dance: after the sphere of the fixed stars, the five planets, and after them, the Sun, beneath that the Moon, beneath this the Earth, beneath that the counter-Earth; and after all of these comes fire, which is at the center in the position of the hearth.

Rossmann claims that Stobaios' report that Philolaus mentioned *two* fires, means that he could not have identified "fire" with the Sun, and the mention of a "counter-Earth" *and* the Moon, means that the two could not be the same object.

It is also on the basis of the sole testimony of Stobaios, that English-speaking scholars such as Heath and Hicks sought to construct some rationale for there being *both* a Moon and a "counter-Earth" in the Pythagorean hypothesis.[9] The only conceivable rationale, or rationalization, is that the Pythagoreans perhaps thought that a "counter-Earth" is necessary to explain the phenomenon of eclipses. Such a rationalization is obviously unnecessary, since Thales of Miletus knew perfectly well that the Moon causes eclipses, and he is even credited with having predicted one. Again, there would be no need for the rationalization at all, were it not for the gullibility of scholars who believe Stobaios is a legitimate source for the real teaching of the Pythagoreans.

Perhaps the reader will agree that this testimony against Kepler is extremely weak. That impression, I believe, is strengthened if one considers that Stobaios was a popularizer of scientific and literary lore of times which were already "antiquity" to him: He wrote in the 5th Century A.D., and it is hardly possible that his sources were better than those available to Aristotle or Theophrastus. The transmission of the testimony of ancient sources often resembles the children's game of whispering in a telephone-circle: The last child to attempt to say what was originally said, is generally far from the mark. So, although Aristotle lies, he may be taken to be a sufficient source of the argument Kepler made against him.

George Gregory is currently completing his doctoral dissertation on Plato's Republic. *Several of his translations from German have been published in* Fusion *and* 21st Century, *and his translations of works by Schiller appeared in the three-volume* Friedrich Schiller: Poet of Freedom *(Washington, D.C.: Schiller Institute, 1985-1990).*

Notes

1. The translation of the Laws is that of A.E. Taylor in Edith Hamilton and Huntington Cairns, eds., *The Collected Dialogues of Plato,* with minor changes for the sake of the literal sense.
2. When does the slower of two planets appear to be the faster? Imagine a distant comet travelling directly toward Earth. For observers on Earth, it would exhibit no motion across the "surface" of the heavens at all. It would seem motionless—until, eventually, observers noticed that it kept getting bigger! Thus, the faster of two planets can be in a part of its orbit in which much of its motion is toward the Earth, while the slower planet happens to be alongside the Earth—so that nearly all of its motion is seen as transverse motion against the heavens. Then the planet that is actually slower may be measured by Earth observers as moving faster against the sky.
3. Seth Benardete, *The Argument of the Action: Essays on Greek Poetry and Philosophy* (Chicago: University of Chicago Press, 2000). See the beginning of the chapter, "The First Crisis in First Philosophy," p. 3.
4. The translation of the *Republic* is that of Allan Bloom (New York: Basic Books, 1968), with minor changes for the sake of the literal sense.
5. Or "truly fast" and "truly slow." The emphasis, of course, is mine.
6. When used in the context of mathematics or logic, *problema* is generally translated as a simple transliteration, that is, "problem." In its more general usage, however, it meant something which "juts out," or something set up as a defensive barrier or obstacle, like a wall. This sense is relevant to the crucial issue in geometry of incommensurable magnitudes, which the Stranger in the Laws dialogue introduces just prior to his discussion of astronomy. Most Greeks, he says there (818e ff.), believe that all magnitudes are commensurable, but they are not: that is, there is a "barrier" or "obstacle" to measuring the internal geometrical features of all figures with the same units. Incommensurable magnitudes are, therefore *the problem,* the barrier which alerts us against trying to apply units of measure to the movements of planets as they present themselves in the form of "observable fact."
7. Fritz Rossmann, ed. *Nikolaus Kopernikus: Erster Entwurf seines Weltsystems, sowie eine Auseinandersetzung Johannes Keplers mit Aristoteles über die Bewegung der Erde* (Munich: Rinn, 1948). A later edition was issued by Wissenschaftliche Buchgesellschaft Darmstadt in 1986.
8. My translation of the German.
9. Sir Thomas Heath, *Aristarchus of Samos: The Ancient Copernicus* (Oxford: Clarendon Press, 1913), Chapter 12, "The Pythagoreans."

Will the U.S. Join the World Fusion Effort?

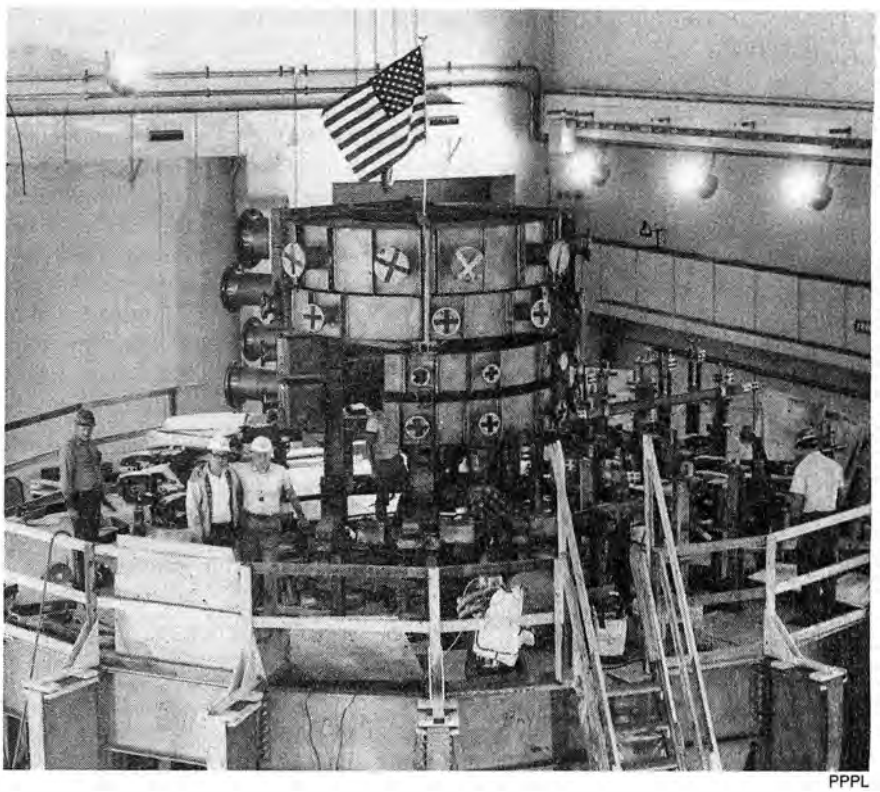
by Marsha Freeman

In July 2001, the European Union, Japan, and Russia came to agreement on the design of the world's first continuous-burn fusion device. The United States was conspicuously absent. Construction of the machine, which is the next step in harnessing the virtually unlimited energy supply of controlled thermonuclear fusion, will begin in 2003.

Twenty years ago, the United States led the world in the number and range of experimental facilities for research in thermonuclear fusion. Since then, the development of this potentially unlimited energy source fell victim to the short-range thinking promoted by the "shareholder values" of the era of globalization, where any activity that does not show an immediate payback is not worth investing in.

Government policymakers have not sought to try to "privatize" fusion research yet (as they have proposed for everything from the Space Shuttle to public schools); instead they have simply chosen to ignore it. During the Clinton Administration, the Congress was unwilling to continue to commit resources to such a long-term effort. The Bush Administration has promoted an energy policy that foolishly relies almost entirely upon the short-term exploitation of petroleum and natural gas.

But the rest of the world is not so short-sighted. According to Dr. Anne Davies, director of the Office of Fusion Energy Sciences at the U.S. Department of Energy, at present, the U.S. fusion program represents merely one sixth of the international effort. Even the cash-strapped Russian government accounts for a larger share—20 percent. The nations of the European Union have the most wide-ranging fusion program, and are now responsible for half of the resources committed to fusion research, in the world.



PPPL

The TFTR tokamak under construction in 1982, at Princeton Plasma Physics Laboratory. The U.S. Magnetic Fusion Energy Engineering Act, signed into law by President Carter on Oct. 7, 1980, specified an engineering reactor to be built by 1990, and a commercial prototype by the year 2000. But the Act was never funded by Congress, and the tokamak program, as well as many other types of promising U.S. fusion research devices, were killed by budget cuts.

A description of ITER and how fusion works appears on the inside back cover.

A World-Wide Fusion Effort

In 1985, at the first Reagan-Gorbachev summit meeting, the two leaders agreed to collaborate in order to design and construct the world's first operating experimental fusion reactor, a proposal that had been formulated by Academician E.P. Velikhov. Subsequently, the European Union and Japan were invited to join, and several other countries, including Canada, also participated. The project was known as the International Thermonuclear Experimental Reactor, or ITER.

Scientists from more than a dozen nations contributed to the theoretical research to understand the behavior of high-temperature plasmas, and the engineering and component design work that an operating reactor would require.

By 1997, the first-generation overall design work for the international fusion experimental reactor was completed, with ambitious design goals, and a price tag of $8 billion. But federal budgets for scientific research, particularly in Russia, the United States, and Japan, were on the decline.

The next year, technical specialists from the United States, Russia, and Japan reported that the projected capital cost of ITER could be cut by 40 to 50 percent if the performance objectives were reduced, making the actual construction of the reactor more feasible, while still meeting the ambitious goal of producing hundreds of megawatts of fusion energy.

As this redesign work was proceeding, the six-year ITER Engineering Design Agreement among the international partners came up for renewal, in July 1998. It was proposed that the engineering design phase be extended for three years, to 2001, when a decision on a final design and a commitment would be made to build the international fusion device.

The U.S. Bows Out

In the summer of 1998, the fiscal year 1999 appropriations bill to fund the Department of Energy eliminated the $12 million the Department had requested to continue work on ITER. The bill included "language" in its report that no funds for ITER engineering design work were obligated past fiscal year 1998, and could not be, without concurrence by Congress. The Clinton White House was not able to sway the Congress.

On June 25, 1998, House Science Committee Chairman James Sensenbrenner (R.-Wisc.) wrote to Energy Secretary Frederico Pena, urging him to delay signing the ITER extension agreement. On July 15, Fusion Power Associates director Dr. Stephen Dean, wrote to Sensenbrenner, asking him to reconsider:

"Yesterday the Government of Japan signed the three year extension agreement to continue the ITER international collaboration on fusion energy development. The European Union and Russia signed previously, leaving the United States the only Party whose signature is not on the line."

The agreement, Dean stated, simply commits "the United States to work in good faith with the other Parties to develop fusion as a future energy source, and I hope that you will agree with me that it is in the interest of our children and grandchildren that we do this."

Sensenbrenner was not moved. In September, he reacted angrily to Energy Secretary Bill Richardson's agreement at an international conference in Vienna, to extend U.S. participation in ITER for one year. "The project has failed," Sensenbrenner railed, "and it's time to move forward. It defies common sense that the United States should agree to continue to participate in a dead-end project that continues to waste the American taxpayer's dollars."

Energy Secretary Richardson's attempted end-run around Congress was short-lived. The only funds that Congress would appropriate for Department of Energy work on ITER were enough to close out U.S. participation in the design activities of the program.

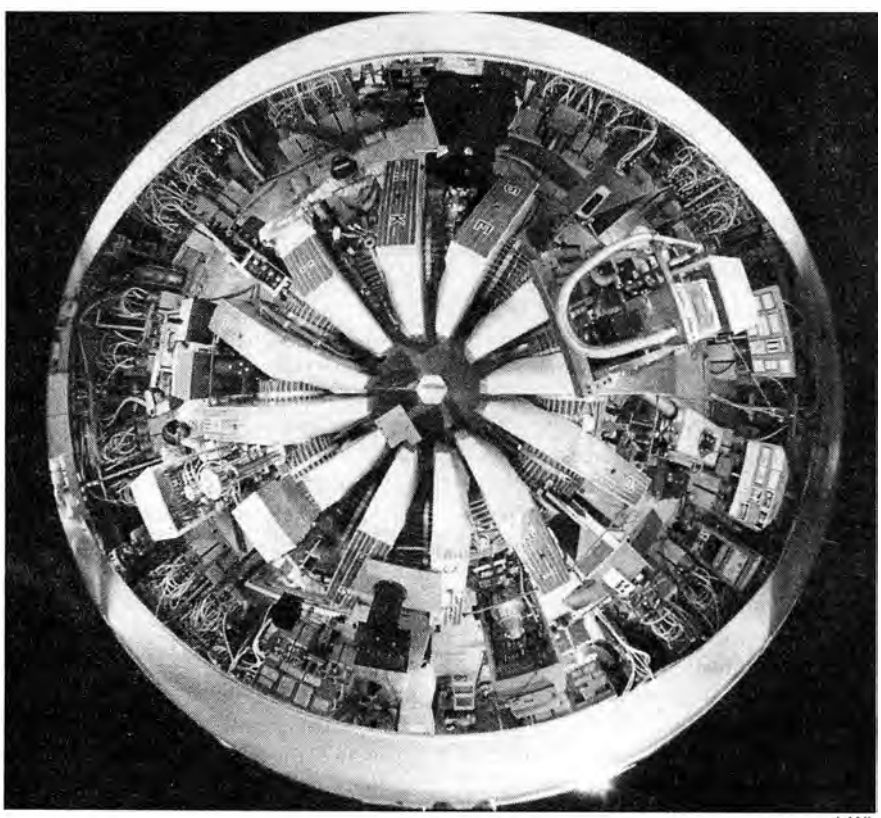
For the past three years, the international partners have continued work on ITER, recently completing the engineering design activity, without official participation by the United States.

The international partners, particularly Japan, have tried to lobby the United States to reenter the project. During a trip to Washington in May 2000, Japan's Minister of State for Science and Technology, Hirofumi Nakasone, issued a joint statement with Energy Secretary Richardson, once again recognizing "the potential value of ITER in developing the scientific basis to promote fusion as a viable energy source."

On April 3, 2001, the Japanese Atomic Energy Commission approved a report by Japan's ITER Special Committee, and released it for public and government circulation and comment. It states: "At present, it is difficult to accurately estimate the overall cost for the realization of fusion energy. Moreover, it is almost impossible to estimate the profit from the realization of fusion energy. It can be understood that the investment in developing fusion energy is regarded as a sort of insurance premium for securing a wider degree of freedom for humankind in the future."

On June 5, the Japan Atomic Energy Commission approved the final report, noting that "it would be of great significance for Japan to host ITER in addition to participating as a key member."

On July 17, 2001, the International Atomic Energy Agency (IAEA), marked the official completion of the engineering design for ITER, describing it as a "landmark achievement in fusion energy research." The IAEA noted that ITER "will be capable of generating 500 megawatts of fusion power for hundreds of seconds," and could "lead to the construction of a demonstration fusion power plant that generates large



LANL

The ZT-40, a reversed field zeta pinch fusion device at Los Alamos National Laboratory. This is another line of promising fusion research that was stopped by lack of funding, although it had already been demonstrated that the concept could work. Other smaller reversed field pinch experiments around the world are in progress.

amounts of electricity."

During a meeting held in Vienna July 16-19, delegations from Japan, the European Union, Russia, and Canada agreed to start the next step—negotiations for the plan to implement ITER construction by the end of 2002. In a meeting in Toronto the week of November 5, 2001, delegations of the international ITER participants began the negotiating process. A second meeting will be held in Japan in January 2002, and Japan hopes the United States will be attending.

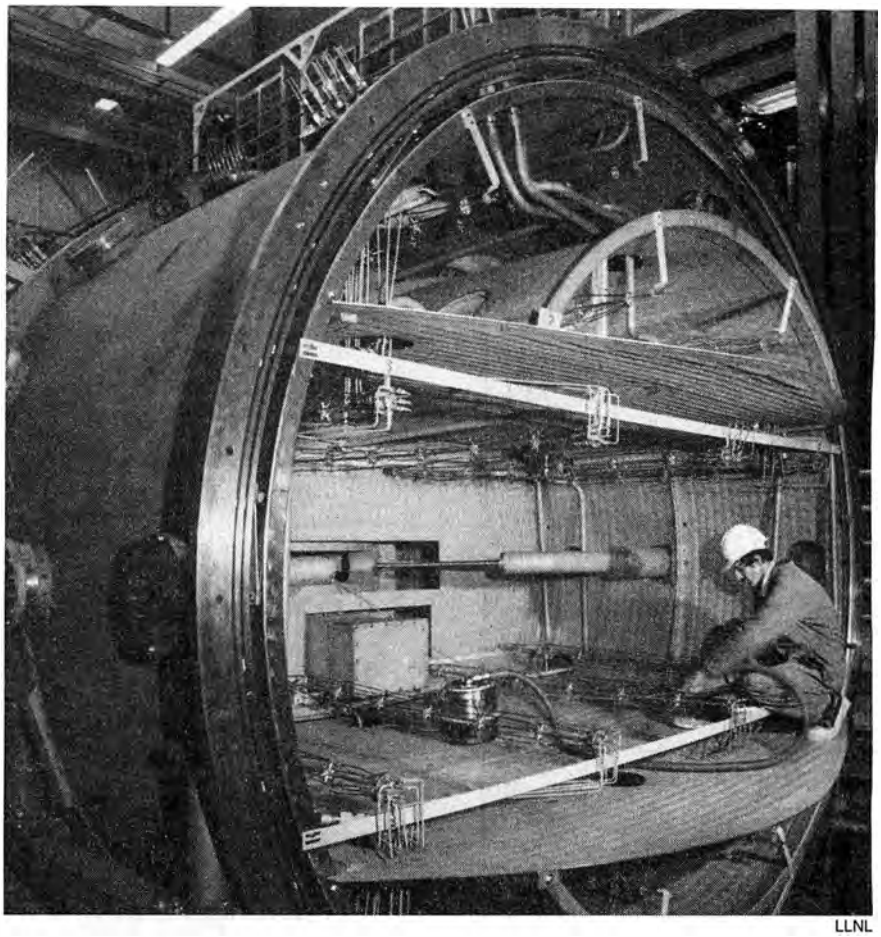
On September 6, Koji Omi, Japanese minister for science and technology, informed U.S. Energy Secretary Spencer Abraham in Washington that Japan has made a formal request that the United States return to the ITER project.

Lobbying Efforts Make an Impact

Apparently, the lobbying by U.S. fusion scientists, the international partners, and especially Japan, has had some impact. At the end of October, DOE fusion head Dr. N. Anne Davies reported that the United States would be a partner in one of the handful of working groups—the International Tokamak Physics Activity—established by ITER to support the theoretical underpinnings of building an operational device. This working group aims to foster cooperative research for advancing the understanding of a burning fusion plasma. This work will be carried out under bilateral agreements between the United States and each of the major partners; the United States will not rejoin the project as a whole.

At the beginning of November 2001, the leadership in the House Science Committee added its voice to those pressuring the United States to rejoin ITER. Reps. Sherwood Boehlert (R.-N.Y.), and Ralph Hall (D.-Tex.), the chairman and ranking minority members of the Committee, respectively, wrote to Energy Secretary Abraham, stating that the United States "should send a representative, at least as an observer, to the follow-up [ITER] meeting now scheduled for Tokyo."

"The current ITER proposal merits consideration," they wrote on November 1. "The current ITER initiative is based on a design that is half the cost, or less, than the original. . . . The burning plasma experiment that would be conducted at ITER is the next logical step toward understanding the physics of fusion reactors."



LLNL

The Tandem Mirror Experiment at Lawrence Livermore National Laboratory, was also shut down by budget cuts. The Russians are currently using a mirror device, along the same lines as the tandem mirror, which produces a small amount of fusion for purposes of materials testing.

However, unwilling to stick their necks out too far, the Congressmen continue, "while we are not ready to offer our unqualified support for this initiative, we do believe exploring the current ITER options makes sense. . . . Time is of the essence with the ITER initiative and the U.S. should begin to assess the project's feasibility, evaluate what role the U.S. might play in it, and participate in discussions to refine the project and select a site. We have been approached by both the Japanese and Canadian governments about this matter, and they are eager to have the U.S. join the discussions."

"If we do not begin to examine ITER soon, we may lose the chance to join as a partner," Congressmen Boehlert and Hall conclude. The Department of Energy needs the sanction from the Congress before the U.S. can reverse its withdrawal from ITER.

Europe, Japan, Russia, and Canada are ready to choose a site and start to build an international thermonuclear experimental reactor. The question is, will the U.S. contribute its expertise and resources to that effort?

Choosing a Home for ITER

At the annual meeting of Fusion Power Associates (FPA), held at the Embassy of Canada in Washington, D.C. on September 25-26, 2001, ITER Director Robert Aymar reported that the plan for the approximately $4 billion machine is to have the goal of producing 500 to 700 megawatts of fusion energy. He estimated that it would take four years to build ITER.

By the end of 2002, he reported, there will an agreement to build, a legal certi-

Continued on page 50

INTERVIEW WITH SATORU OHTAKE

Japan Urges U.S. to Rejoin Fusion Project

Associate Editor Marsha Freeman interviewed Mr. Satoru Ohtake, Director for Fusion Energy of the Ministry of Education, Culture, Sports, Science, and Technology, on Dec. 5, 2001, at the Japanese Embassy in Washington, D.C. Mr. Ohtake was in Washington to discuss ITER with U.S. energy officials.

A full version of the interview will appear in Executive Intelligence Review.

Question: What is the purpose of your visit to the United States?

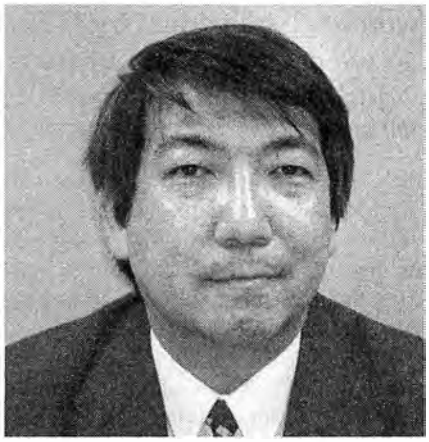
I came into this position of Director of Fusion Energy in mid-July, and have worked since then mainly on ITER. It is necessary to secure large-scale resources and a fixed, rigid international framework for that program. The discussion in Japan about whether or not to participate in ITER or, furthermore, to host the experiment, is continuing, and in that discussion, the attitude of the United States is very important.

As you know, ITER has been in preparation for a very long time, about 15 years, from the very initial stage. For the past 9 years, the countries concerned have carried out the preparatory study and conceptual design activity, leading to an engineering design. These 9 years ended in July, and the engineering design is completed.

The United States initially was a member but, unfortunately, three years ago there was some discussion in the United States and there was a misunderstanding or conceptual change there, and the United States got out of the circle in 1998. Now, ITER is ready to come up to the full-fledged phase of construction. At this time, I think it is necessary to come to the United States and discuss with the people concerned, the U.S. re-entering the project.

Question: Why is it important that the United States to rejoin the ITER project?

Because regarding ITER, we—meaning Japan, the European Union, Russia, and Canada—are quite ready and confident and have enough engineering technology background to realize ITER now. But it is an international program, so if the United States re-entered ITER, it would be more, or really, international.



Fusion Director Ohtake: "We are ready to start to build ITER."

Question: The Japanese plan, then, is to try to encourage the United States to re-enter. But it seems to me that the partners are making a commitment to go ahead and construct ITER, even without the United States. Is that the case?

Frankly, U.S. re-entry is quite important, but not conditional. It would be better, but is not inevitable. . . .

[A]fter constructing ITER, we will have a burning plasma, and this is an essential and important step to make nuclear fusion into a source of energy. We can share this goal with all of the international partners who have the potential to carry out this kind of scientific and engineering work. We are open to every country and also to the United States, especially, because we are old partners and, there is no doubt that the United States has a top, world-class fusion potential. So, we encourage them to re-enter. It is up to the United States to decide, but what we can do is encourage.

Question: Are there other countries that have expressed an interest in participating in ITER?

Yes. China showed an interest in ITER first, and Korea expressed an intention to participate. China shows a very apparent interest. We are glad to have a sign or proposal from other countries to get into ITER, because they can contribute real work. Each members has to contribute. It is necessary to have some statement from the newcomers, a commitment.

Question: If a country wanted to participate in ITER at this time, going into the construction phase, how could it contribute?

If they do not have the potential to contribute hardware, cash is also needed. Each member has to contribute hardware or cash. They would enjoy participating in the learning phase. And in the operational phase, they will have a chance to do experiments.

ITER will produce a burning plasma continuously for several minutes or several hours. It will be the first time for us to have a fusion system on the ground. Scientists or researchers, and engineers would like to do experiments. From the scientists' point of view, they want to know what is going on in a burning plasma, which is a complex system, quite different from the elementary particle question, or something like that. It's a very huge, complex system.

From the engineering side, they would like to know how to produce energy from the burning plasma, using some apparatus for exchanging the energy of the fusion neutrons, to produce high pressure water, which will require some intermediate process. ITER is an engineering reactor, so the goal is not to make energy on a full scale, but some engineering phase or trial to take boiling water will be carried out, and in some cases, we can produce a small generation of power, as well.

Question: What is the schedule now for ITER?

The schedule for ITER now is that we have to make the so-called joint implementing agreement between the parties. This is the legal framework, which will provide the duties and rights of the parties. This work will continue up to the end of 2002. In order to finalize the draft of the joint implementing agreement, it is necessary for us to decide a site, and we are scheduled to decide in the mid-

dle of 2002, in May, or a little later.

As you know, Canada has already offered a candidate site, and Europe is finishing a technical assessment of Cadarache, in the south of France. Spain, a European Union member, has given a very preliminary intention to invite ITER there. Their technical assessment is not finished; just their intention was shown.

In Japan, we have finished the domestic site assessment, which is a technical assessment, but we haven't yet confirmed a conclusion about a site, as the Japanese government hasn't yet decided on a formal position in ITER. The discussions are now continuing on whether we will be hosting ITER, but we have finished the technical assessment of the sites.

Three prefectures (we have 47, like your states) offered, or showed an intention, to host ITER. They were Hokkaido, Ibaraki, and Aomori. After the technical assessment, Ibaraki and Aomori are eligible for the building of ITER. So we have at least in Canada, the Clarington center, one in France, maybe Spain, and two eligible sites in Japan. Now that we have at least three candidates, we can discuss making a joint site assessment and discuss cost sharing. Then we will finalize the agreement. In some countries, the agreement will need to be ratified, like a treaty.

"Even if ITER is a great success, we need a domestic fusion energy system. Our energy security in Japan won't be solved just by ITER, so we need to have our own fusion system in Japan."

We hope to start the construction phase in 2003. It will take two years to establish the international organization to carry out the construction, operation, and decommissioning of ITER. The construction will take 10 years.

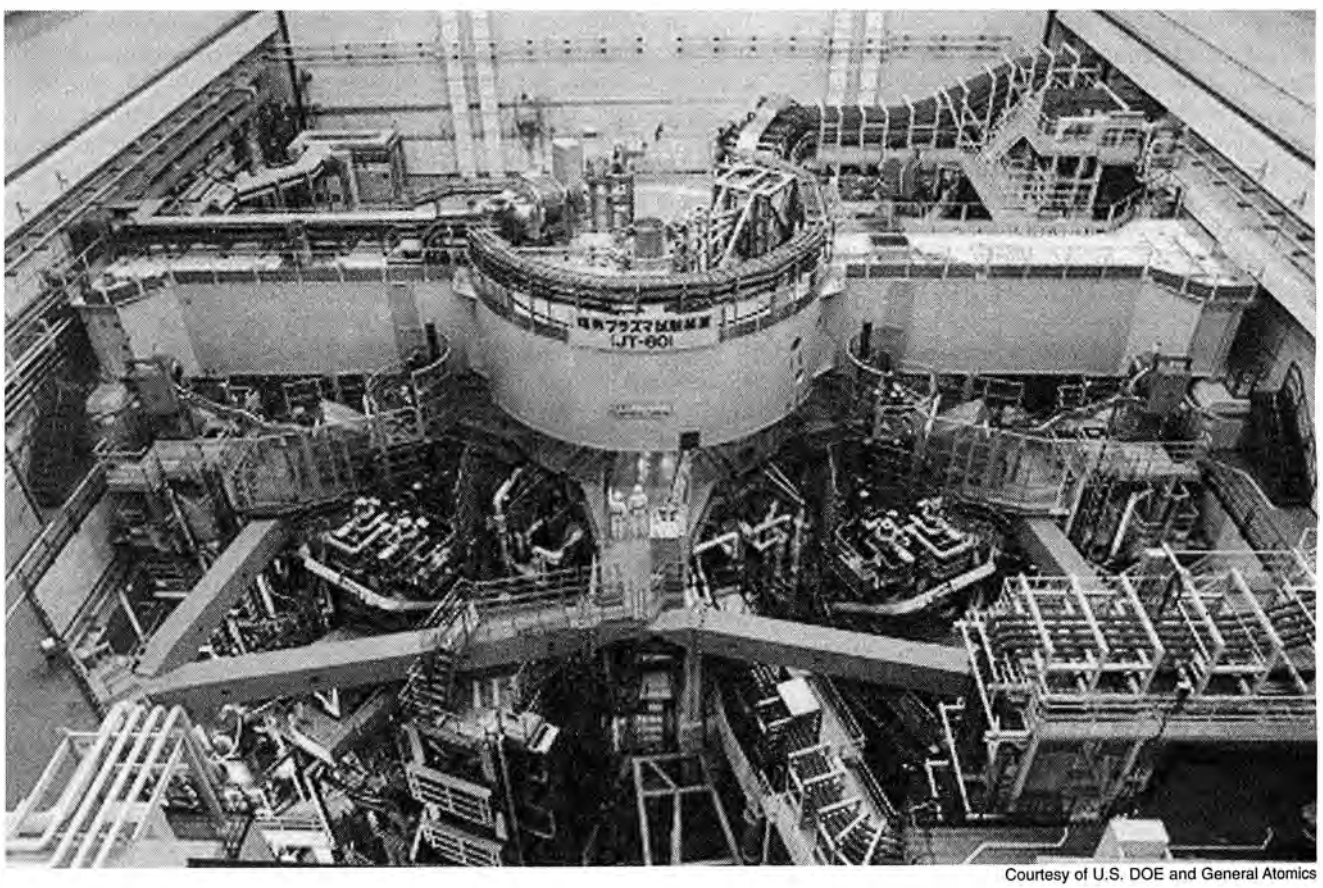
Question: Why will it take that long?

Because there are many high-technology parts, such as the toroidal magnets. There are 19 such superconducting magnets, which require new materials. Making the superconducting wire takes a lot of time and is very difficult. It has a complex structure. In Japan we have a stellarator machine, which has a very long helical magnet, and to wind up this magnet takes two years! Then the magnet will have to be tested, and finally it will come to ITER.

The construction process can possibly be shortened by two or three years.

Then we are in the operational phase, for at least 20 years. For the first 8 to 10 years, we will be "warming up" ITER. First, there will be experiments introduced with a simple hydrogen plasma, in order to test and condition the metal machines. Then, they will introduce the deuteron, or double hydrogen. Finally, they will introduce deuterium and tritium to produce the real fusion phenomenon. Then they will start real engineering and science experiments.

For example, we will introduce a new type of blanket, which will be used to pull energy from the burning plasma and



Courtesy of U.S. DOE and General Atomics

An overview of the JT-60U, one of Japan's large tokamak devices.

convert the neutron energy into high-pressure boiling water. Or, we can use the fusion neutrons to make tritium. Fusion neutrons can be used together with the light metal lithium, and you have tritium. That is one of the advantages of fusion, that it can produce energy and its own fuel. We will have about 10 or more years of energy experiments. Engineers and scientists will get the results and we will have enough experience to transfer it to the energy-producing machines from the experience on ITER.

Question: There is concern in the United States that if money is spent on international collaboration, there may not be funds for a robust domestic fusion effort. How is this viewed in Japan?

We have the same issues in Japan. After the reform last January, almost all of the fusion programs in Japan are under the supervision of my office, in the Ministry of Education. This allows us to organize all of Japan's fusion resources.

Courtesy of U.S. DOE and General Atomics

Inside the donut: A Japanese engineer standing inside the JT-60U torus.

The real problem is that there are limited resources, which we must know how to allocate properly. ITER is an international, single-purpose machine. Its major purpose is to produce a burning plasma, and to make sure of the possibility of fusion as an energy source. That is the major purpose of the machine, not science.

It is necessary to maintain good potential fusion science research in Japan, for two reasons. First, because compared to the United States, in Japan our energy problem is very serious. We have no petroleum sources, as you do in Alaska, or Texas, so energy is quite an important issue. Even if ITER is a great success, we need a domestic fusion energy system. Our energy security in Japan won't be solved just by ITER, so we need to have our own fusion system in Japan.

Second, ITER is a very long-term project. As I joke, when ITER is finished, I will be retired. So we must continue to secure good human resources and personnel regarding fusion research in Japan. Scientists will work on ITER, carry out good experiments, and then return back to Japan and advance the results in the research in many ways. We need top-level plasma machines in institutions in Japan, in parallel with ITER. We must maintain plasma science.

In many institutes and in universities, there are small plasma machines in Japan. It is apparent that it is not realistic to have ITER, in addition to all these small machines all over Japan. So we started discussing our plasma science programs with all the university directors of fusion science, and how to improve Japan's domestic fusion program. We have six or seven mid-size or big-scale machines now in Japan, but probably in the future we will have three or four advanced top-class machines, and all the universities and laboratories will cooperatively use these machines.

For very small machines, it's okay to have many, because they do not cost much, so they will maintain these machines using research grants.

Some middle-scale machines, if they would like to keep them, will only get "out of fashion," and not be involved in the top-level research, so they have to change. They can share time on the top-class machines, which is also done with accelerators. I have been discussing this with many university professors, and they are now aware of the situation. The Japanese economic situation is *so* bad, it is not easy to have so many devices, or a plentiful budget from the finance authorities for the fusion programs. We should have the best use of the limited budget to maintain fusion research.

Question: What kind of financial commitment would be required for Japan to host ITER?

During the construction phase of ITER, the peak in the annual budget for the host country will be about $400 million. The total ITER cost will be 1.2 trillion yen, or about $10 billion over 35 years. This includes, in the final five years, the cost of decommissioning. The host country, if it is one of the three major partners, would be responsible for 50 percent of the total budget, or about half, of the cost.

If Japan were to host ITER, at some time in the construction phase, it would cost $400 million for the peak funding year, which would compare to the $200 million that should be budgeted for the domestic program every year. So we need to add double to our resources to host ITER.

Question: When will Japan decide if it will participate in the construction phase of ITER, and offer a site to host the project?

Japan is still discussing this. The Atomic Energy Commission has decided on participation, and now the supreme advisory board, the Council for Science and Technology Policy, which is chaired by the Prime Minister, is discussing it. They have issued an interim report. They recognize the importance and meaning of ITER, but will want to be convinced about its cost-benefit. Participation is assured, but hosting ITER costs double the resources, so they will think about it. If there is additional money, they will say yes, but the current situation is very severe, so they are doing everything imperfectly.

I hope that they will come to the con-

clusion that Japan will be hosting ITER. I feel fusion is a very difficult program. We need to have the experience of a burning plasma, and then be sure it is a good candidate for a future energy source. We have to pass this very high-level challenge.

Question: People here often say to scientists, "you have been working on fusion research for 30 years, and we still do not have it. Why do you still keep doing it?"

In the case of fusion energy, people don't know very much about it. In Japan, the case is the same. Fusion is something like a mirage because some of the researchers said in the 1970s that in 30 years, you can have energy. Now 30 years have passed, but still we say, 30 years from now. Some of the leading politicians in Japan say this, so we have been discussing this.

We do not have so many possible energy choices. Of course we have some renewable sources like solar energy or hydrogen. But solar energy is not a large-scale energy source. It should be a local, complementary energy source, but it is not possible to replace oil burning systems, or coal systems, or nuclear fission reactors with it.

Hydrogen should be a secondary energy, like gasoline for cars, because it is necessary to have a strong electricity source, or hugely powerful source of high temperature to produce the hydrogen. So fusion is one of our future choices. That is why we pursue this possibility. It costs a lot, I know, but if we can be successful with a burning plasma, a very convincing new alternative will be assured.

Question: In the United States, fusion research has received very little funding or public attention. How would participating in ITER help that situation?

ITER is a great international, and very encouraging, endeavor. If we introduce the question of U.S. participation, we can reinvigorate the discussion in the United States. I think we are ready, in any case, to start to build ITER. But for fusion science, for all human beings, it is better for the United States to participate. The United States' potential to carry out fusion research should be reinvigorated, and it will be of great help for all human beings. That is what I honestly feel.

Will the U.S. Join?

Continued from page 46

fication, and an entity created to procure the license and constructor. After the United States withdrew from the project, he said, there was a lack of agreement as to where it should be located. Canada submitted an offer in June 2001, and Europe and Japan are currently preparing bids.

"There is no technical justification for postponing a decision to build ITER," Aymar said. In Europe, "if it is not done, fusion will be reassessed, and it won't be so positive." He concluded: "The time for ITER is now."

On June 7, 2001, at an ITER meeting in Moscow, the Canadian government announced that it is offering the Clarington site, near Toronto, as its proposed bid to house ITER. As Dr. Peter Barnard, Chairman and Chief Executive Officer of ITER Canada, explained at the FPA meeting, the project was supported by government offices, labor interests, universities and professional societies, and the private sector.

Canada is offering to supply the infrastructure and supporting services for the project, while the other countries would supply most of the components.

The Clarington site is desirable, Barnard said, because the Darlington nuclear station is located there, and there is a tritium removal facility on site, as well as the largest cement factory in North America.

Dr. Barnard estimated that the buildings and infrastructure from the host country, were ITER to be built in Canada, would require about Canadian $1 billion, and operating support, somewhat less than that amount. He also stated that were ITER to be built in Canada, it would increase the likelihood that the United States would rejoin the project.

Jean Jacquinot from France described the site at Caderache as a possible home for ITER. There is infrastructure already there, such as a nuclear research center with 4,000 people, and 18 nuclear installations. The local government, Jacquinot reported, would contribute money for construction. He reported that a detailed study is under way, and that in a few months, the European Union would decide on a proposed European site.

Mr. Kiochi Morimoto, Science Counselor from the Embassy of Japan, who participated in the Japanese ITER design work, reported that there was a competition held in Japan for local governments to offer sites for ITER's construction. They received three proposals, and will be choosing two possible locations. At the FPA meeting, Mr. Morimoto stressed that Japanese government officials had come to Washington to request that the United States reconsider rejoining the project.

Dr. Lev Golubchikov, director of fusion energy in the Russian Ministry of Atomic Energy, reported that in August, the Russian government had approved the fusion program for the next five years for ITER. He explained that ITER is 75 percent of Russia's national fusion program budget. Although Russian scientists have a variety of fusion experiments they would want to pursue, now, and while ITER is being built, resources are scarce, Golubchikov reported.

Presentations at the FPA meeting were also made on other current and possible fusion experiments in laboratories around the country, including burning plasma devices.

FPA head Dr. Stephen Dean stated that the United States needs a "robust national program," to determine how to best develop fusion. The physics of tokamaks, for example, can be studied in machines smaller than ITER. In addition, ITER will not be fully operating for another 10 years, so new, smaller machines are necessary, in addition to the upgrade of existing facilities.

There should be a vigorous program also to investigate alternative approaches to produce magnetically confined fusion than the tokamak, Dean stated, or we "may miss a better approach." Nevertheless, he said, the United States should be participating in the international fusion effort, which would mean funding the fusion technology development programs that have been sacrificed to tight budgets. Then, the United States would really be able to contribute to ITER.

The U.S. rejoining ITER, Dean said, would be a "boost up," for the nation's fusion effort. It would "gain the attention of Congress and heads of state, who would start taking fusion more seriously."

The U.S. still has the opportunity to reenter the ITER program, but time is running out.

The Case for *Adult* Stem Cell Research

by Wolfgang Lillge, M.D.

THE STEM CELL DEBATE

Controversy Reignites Over Stem Cell

SHERYL GAY STOLBERG

...INGTON, Dec. 17 — When Presi... announced on Aug. 9 that the ...nt would pay for certain studies ...n embryonic stem cells, many ...s thought he had settled the stem ...e, at least until the initial ...

...setts biotechnology company, Advanced Cell Technology, that it is trying to clone human embryos for stem cells has reignited a controversy in Congress over the ethics of embryo experiments. A debate that was virtually extinguished by the Sept. 11 terrorist attacks is now very much alive. The next battleground will be the Senate, where ... early ...

...executive director of the Alliance for Aging Research, an advocacy group that promotes stem cell science. "It was a temporary compromise that allowed voices on both sides to be calmed temporarily."

At the heart of the debates over stem cells and cloning are questions that ...

Stem cells, which are extracte... bryos when the embryos are st... tera of no more than 300 cells, a... ing great excitement in scienc... they can, in theory, grow into ... body's cell types. Scientist...

THE NEW YORK TIMES OP-ED MONDAY, AUGUST 27, 2001

STEM CELLS

NIH Pulls Plug on Ethics Review

Advocates for research with huma... onic stem (ES) cells are worried by... ...vist in the cells' politi... ...

What Only the Embryo Knows

By contrast, von Baer proposed a principle of progressive specification and differentiation: One can first tell that an embryo will become a vertebrate and not some sort of invertebrate, then a mammal and not another ... cussed and little understood, in our current debate over embryonic stem cells. The very structure of material reality imposes a principle of trade-offs in both nature and human affairs: One always gives something in order to gain. In particular, we ... of cells at a young age to "dedifferentiate," or return to a state of early embryonic flexibility — becomes progressively lost in animals that ...erwise greater adult complexity by ...von Baer's universal process of "locking in," with increasing specialization of parts. We have, in short, ...

STEM CELLS

DFG Gives Embry... Research a Boost

BONN—Germany's main researc... agency issued new guidelines ... paving the way for researchers to ... man embryonic stem (ES) cells ... countries. The Deutsche Forschu...

THE STEM CELL DEBATE: Patients, Politics and Potential Treatments

PERSONAL HEALTH

Weighing the Rights of the Embryo Agains...

By JANE E. BRODY

In theory, millions of people suffering ... Chances are everyone knows someone with a debilitating disease whose health and life could be vastly improved if it were possible to use stem cells ... both have endured myriad complications of diabetes, including vision loss, leg ulcers, blackouts and loss of sensation in their feet ... tell them ... Another ...

The question of stem cells is currently the dominant subject in the debate over biotechnology and human genetics: Should we use *embryonic* stem cells or *adult* stem cells for future medical therapies? Embryonic stem cells are taken from a developing embryo at the blastocyst stage, destroying the embryo, a developing human life. Adult stem cells, on the other hand, are found in all tissues of the growing human being and, according to latest reports, also have the potential to transform themselves into practically all other cell types, or revert to being stem cells with greater reproductive capacity. Embryonic stem cells have not yet been used for even one therapy, while adult stem cells have already been successfully used in numerous patients, including for cardiac infarction (death of some of the heart tissue).

Stem cells are of wide interest for medicine, because they have the potential, under suitable conditions, to develop into almost all of the different types of cells. They should therefore be able to repair damaged or defective tissues (for example, destroyed insulin-producing cells in the pancreas). Many of the so-called degenerative diseases, for which there are as yet no effective therapies, could then be alleviated or healed.

It is remarkable that in the debate—often carried on with little competence—the potential of *embryonic* stem cells is exaggerated in a one-sided way, while important moral questions and issues of research strategy are passed over in silence. Generally, advocates of research with embryonic stem cells use as their main argument that such research will enable us to cure all of the diseases that are incurable today—cancer, AIDS, Alzheimers, multiple sclerosis, and so forth. Faced with such a prospect, it is supposed to be "acceptable" to "overlook" a few moral problems.

On closer inspection, however, the much extolled vision of the future turns out to be a case of completely empty promises: Given the elementary state of research today, it is by no means yet foreseeable, whether even one of the hoped-for treatments can be realized. Basically, such promised cures are a deliberate deception, for behind the mirage of a coming medical wonderland, promoted by interested parties, completely other research objectives will be pursued that are to be kept out of public discussion as much as possible.

Perfect candor should rule in stem cell research. This requires that the scientist himself clearly establish the moral limits of his activity and declare what the consequences of research with embryonic stem cells really are. In the process, no one can escape the fact that, should one wish to use embryonic stem cells for "therapeutic purposes," the very techniques will be developed that will also be used for the cloning of human beings, the making of human-animal hybrids, the manipulation of germ lines, and the like—thus for everything other than therapeutic purposes. Any coverup or hypocrisy in this matter will very quickly reflect upon the research as a whole.

What Are Stem Cells, Exactly?

It is appropriate here to sketch the characteristics of stem cells, and the overthrow of some dogmas of developmental biology. Broadly speaking, a stem cell is one that—in the course of cell division and increase in the numbers of cells—is able to reproduce itself and also mature into various specialized types of cells. The stem cell with the greatest potential (totipotential) is the fertilized egg cell, which is capable of developing into a complete organism.

According to the usual—but actually very doubtful—explanation, the fertilized egg cell has totipotential up to the stage of division into eight cells, and in later stages the cells retain only "pluripotential." That is, they can form many different types of tissues, but not the complete organism. Embryonic stem cells—that is, those 50 cells within a blastocyst, which then continue to develop into the embryo proper—have this pluripotential. In the course of further specialization, stem cells of individual tissues are formed, such as that of the bone marrow, from which all the other kinds of blood cells develop.

Behind this description lies the con-

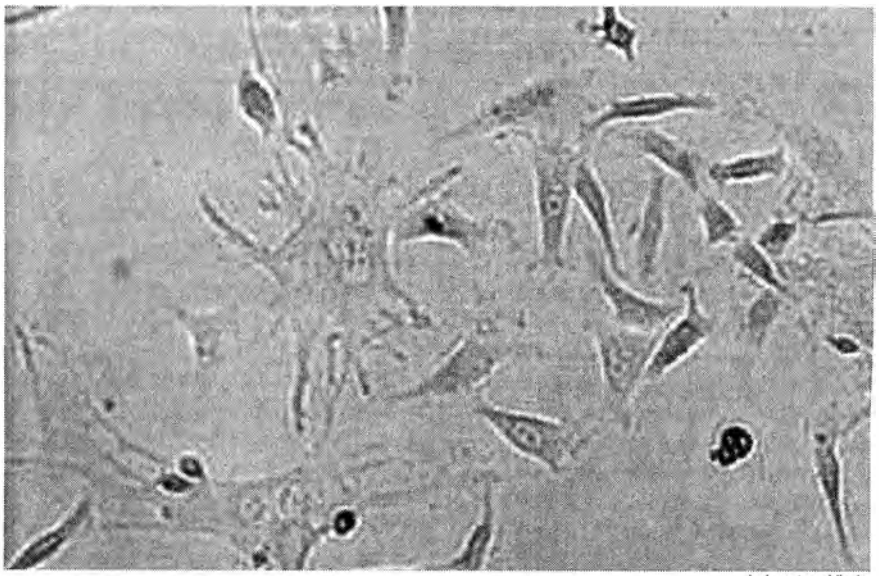
ception that a linear process of differentiation is played out, in the development of the individual, toward increasingly "mature," specialized cells in the individual tissues, from totipotentiality to tissue specificity. This process is supposed to run only forward, but never backward. That is, as soon as a cell has reached a certain degree of "maturity," the way back to earlier stages of development is closed off. So it is evident that a stem cell's capacity to perform is increasingly limited to specific functions, and it loses, correspondingly, the manifold capabilities still present in earlier developmental stages.

According to latest reports, however, this dogma of developmental biology does not hold. Evidently, tissue-specific stem cells have the ability—as has been impressively demonstrated in experiments with animals—to "transdifferentiate" themselves when in a different environment—that is, to take on the cell functions of the new tissue. Thus, neuronal stem cells of mice have transformed themselves into blood stem cells and produced blood cells. Indeed, there are indications of another capability of adult stem cells: Apparently they have the potential to be "reprogrammed." Not only can they adjust to the specific conditions of a new tissue environment, but they can even assume more generalized, earlier levels of development, so that it even appears possible that they become totipotent again.

Problems of 'Therapeutic Cloning'

Until now, talk of a possible source of human replacement tissue has centered on embryonic stem cells, the production of which has been extremely controversial. They are a typical product of "consuming embryonic research," so called, because in obtaining them from a human embryo produced by artificial fertilization *in vitro,* the embryo is destroyed.

The most important research technique for which such embryos are obtained is "therapeutic cloning." In principle, a human egg cell is denucleated, that is, the DNA is removed, and in its place is put the nucleus of a somatic (body) cell. The egg cell is stimulated with a short electrical pulse, and it then develops into the blastocyst, from which stem cells can be removed. These are identical with those of the donor of the somatic cell nucleus.



Laboratory Virola

Laboratory Virola in Ukraine has demonstrated that bone marrow stromal cells in culture are pluripotent—that is, they are able to differentiate into cells of liver, bone, fat, cartilage, and so on. Researchers at this laboratory have developed techniques to differentiate in vitro *mouse bone marrow stromal cells into different types of neuronal and glial cells. The laboratory is seeking funds to develop similar methods for human bone marrow stromal cells.*

Normally it goes unmentioned, that it is only a small step from this so-called "therapeutic cloning" (because, it is claimed, in this way a therapy for diseases can be developed) to what is called "reproductive cloning." The only difference is that the development of the embryo is not interrupted in the early blastocyst stage; instead the embryo is implanted in a uterus and a complete organism develops—an exact genetic copy of the donor. "Dolly," the first cloned sheep, was produced by this method, and here is the basis for the widespread fear that the same method that is used for "therapeutic cloning" can also be used for the selective breeding of humans.

In addition to the obvious moral consideration, there are still other serious disadvantages that make this path to the development of human "replacement parts" appear to be untenable.

The danger of tumors. So far there has been no solution to the problem of developing in the laboratory an unmistakable identifier for stem cells that can distinguish them unequivocally from cancer cells. For this reason, it is also not possible to produce sufficiently pure cell cultures from stem cells. So far, with embryonic mouse stem cells, a purity of only 80 percent has been achieved. That is in no way sufficient for cell transplantation as a human therapy. In a cell culture for therapeutic purposes, there must not be a single undifferentiated cell, since it can lead to unregulated growth, in this case to the formation of teratomas, a cancerous tumor derived from the germ layers. This problem would not be expected with adult stem cells, because of their greater differentiation.

Genetic instability. Only recently a further problem has emerged. Fundamental doubt of the suitability of embryonic stem cells for transplantation has come to the surface because of the genetic instability of cloned cells.

Cloned animals like Dolly give the outward appearance of full health, but the probability of their having numerous genetic defects is very high. Moreover, the entire cloning procedure is extremely ineffective. Most cloned animals die before birth, and of those born alive, not even half survive for three weeks. In the best case, there is a success rate of 3 to 4 percent.

One of the reasons for this high failure rate has now been discovered by the German scientist Rudolf Jaenisch at the Institute for Biomedical Research at the Massachusetts Institute of Technology,

Laboratory Virola

Neuroblasts differentiated from bone marrow stromal cells by Laboratory Virola.

and his colleague, Ryuzo Yanagimachi. Their conception is that in cloning—that is, when the nucleus of a somatic cell is inserted into a denucleated egg cell—the reprogramming of the genes does not proceed properly, so that not all of the genes that are necessary to the early phase of embryonic development, are activated. Even when cloned animals survive at all, probably every clone would have subtle genetic abnormalities that would frequently become noticeable only later in life.

Jaenisch performed his experiments with mice that had been cloned using embryonic stem cells in place of the somatic cells, which produces better results. But to his surprise, the reprogramming of the inserted genetic material by the embryonic cells proceeded in a very unregulated way. There were no two clones in which the same pattern of gene activation was found, and Jaenisch is convinced that the use of embryonic stem cells was clearly responsible.

What consequences follow from this for the therapeutic use of human embryonic stem cells—consequences that will in fact be multiplied through cloning—are not yet foreseeable.

Whoever Would Cure, Must Use Adult Stem Cells

It has been known for about 30 years that stem cells are present in the tissue of the adult, but it was assumed that they could only form cells of a particular tissue. That is, reprogramming them was considered impossible. In recent years, however, pluripotent stem cells were discovered in various human tissues—in the spinal cord, in the brain, in the mesenchyme (connective tissue) of various organs, and in the blood of the umbilical cord. These pluripotent stem cells are capable of forming several cell types—principally blood, muscle, and nerve cells. It has been possible to recognize, select, and develop them to the point that they form mature cell types with the help of growth factors and regulating proteins.

This shows that in tissues of the body, adult stem cells possess a much greater potential for differentiation than previously assumed. This knowledge must be brought into the public consciousness with all possible emphasis. If stem cell research were really only meant for therapeutic uses, which it most obviously should be, adult stem cells would promise a very productive research field—and beyond that, a possibility, without moral objection, to discover fundamentals of the dynamics of tissue differentiation.

It has become clear from transplantation experiments with animals, that stem cells of a particular tissue can develop into cells of a completely different kind. Thus, bone marrow stem cells have been induced to become brain cells, but also liver cells.

Adult stem cells obviously have a universal program for division that is common to all the kinds of tissue stem cells, and makes them mutually interchangeable. This was discovered by Alexei Terskikh at Stanford University School of Medicine in California. He was able to prove that adult stem cells of blood-forming tissues, and of the brain, activate the same genes, in order to preserve their status as stem cells.

In May 2001, a further, spectacular experiment was reported, which was carried out on mice by scientists at Yale University. The researchers obtained stem cells from the bone marrow of male mice, and injected it into females whose own marrow had been destroyed by radioactive irradiation. Eleven months later, the male stem cells (identifiable through the male Y-chromosome) were found not only in the females' bone marrow, but also in their blood, and in their gut, lung, and skin tissues.

If these observations are correct and are confirmed by other teams of scientists, science should concentrate on research with adult stem cells and renounce further experiments with the embryonic.

Human Treatments

Moreover, very promising treatments of serious diseases with adult stem cells have already been tried. The special advantage is that *there are no rejection reactions, because the cells are from the same body.*

Of longer standing is treatment with bone marrow stem cells. The treatment comes into play when, for example, a patient has lost his or her blood-forming tissue through radiation or high-dose chemotherapy. Previously removed bone marrow stem cells are then retransplanted, and are able to resume the formation of blood cells.

In 2001, however, a team of doctors at the Duesseldorf University Clinic carried out a treatment of very far-reaching consequences. For the first time, they treated a cardiac infarct patient with stem cells from his own body. The cardiologist, Prof. Bodo Eckehard Strauer, is sure that the stem cells from the patient's bone marrow, after injection into the infarct zone, autonomously converted to heart muscle. The functioning of the severely damaged heart clearly improved within a few weeks.

Four days after the infarction, the doctors took bone marrow from the patient's

Continued on page 72

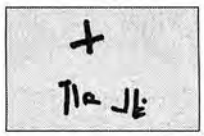
Pitcairn Island Petroglyph Deciphered

by Ross Perfect

The Pitcairn Island petroglyph is located at the base of a steep cliff in a bay known as "Down Rope," at the eastern end of the island. These drawings, which have been the subject of numerous archaeological studies over the past century, have never been fully interpreted. They were first discovered by the settlers from the ship *Bounty* in 1790, together with other native artifacts, and as such were always considered to be Polynesian in origin. However, if this petroglyph is viewed from a Greek/Egyptian perspective, a new story is presented.

The photograph on page 55, and a sketch of its markings, show the entire picture of the petroglyph at Pitcairn Island, which was supplied by the Commissioner of the island, and is included in his publication "Notes for Visitors to Pitcairn Island." In this decipherment, I have extracted each section of the petroglyph, with a detailed explanation for it. The sections have been placed so that the entire picture is read from right to left, and from top to bottom. [Note that, conventionally, white chalk is rubbed over petroglyphs to make the markings stand out in a photograph.]

The top right section appears to be a script depicted by consonants with vowel pointings. With the assistance of the phonetic script developed by Barry Fell,[1] and by reading in a counterclockwise direction from the top, this section is deciphered as follows:



Ph (p)

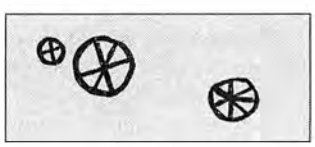
Eng-ari

Phengare = Moon (Greek)

eklei-ekleipo = Be eclipsed.

These three sections together translate as "lunar eclipse."

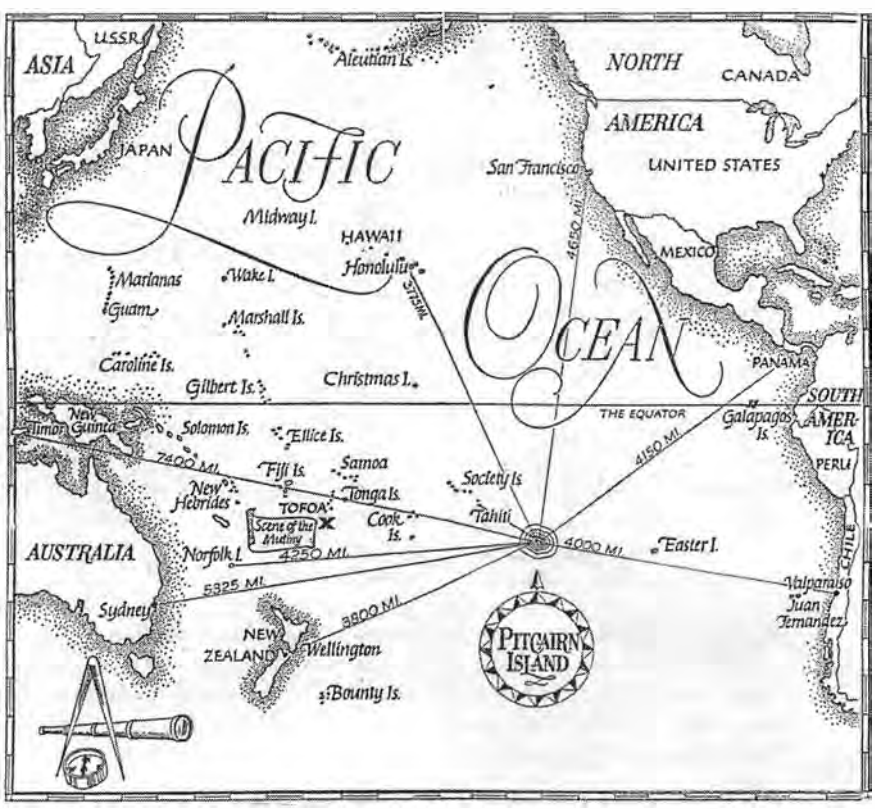
The bottom section in this first area represents three celestial globes: the Moon, the Earth, and the Sun, aligned at the time of a lunar eclipse, with the Sun



casting the Earth's shadow on the Moon. A line from the Sun, in the lower right-hand corner, through the Earth, and then to the Moon, in the upper left-hand corner, shows the Sun to be approaching summer solstice. This occurs when the Sun reaches its maximum southern declination, and would indicate an eclipse that occurred around December.

The next section, the middle portion of the petroglyph, is the date stamp. The five-pointed star represents the Pharaoh or ruling monarch. Underneath the star are the Greek numerals 10 and 6, which represent the 16th year of the reign of the monarch (in this case, Ptolemy III).

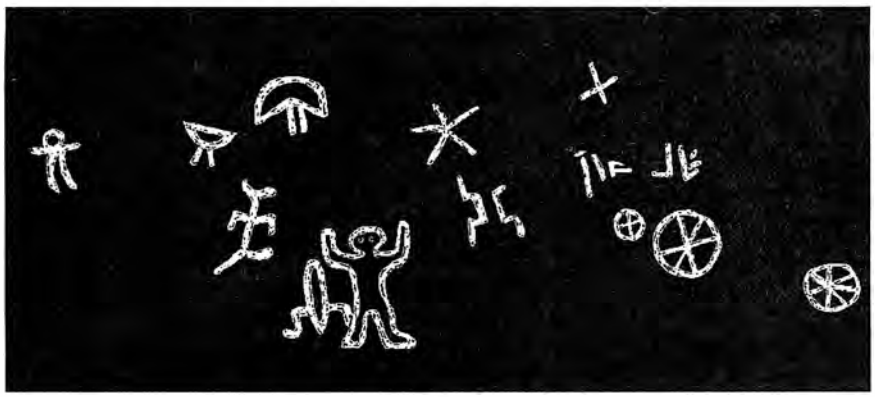
The two hemispherical shapes in the upper-left part of the picture are representations of the Moon near eclipse. On the extreme left of the petroglyph is a symbolic representation of the constellation Gemini. During the eclipse,



Map drawn by Stephen Kraft

Pitcairn Island, made famous as the refuge of the mutineers from the Bounty in 1790, is located in the Pacific Ocean, at approximately 25° South and 130° West.

The petroglyph at "Down Rope," Pitcairn Island. The rock markings have been chalked in, so that they can be seen in a photograph. This photo appears in an official government publication titled "Notes to Visitors of Pitcairn Island," and is also reproduced in a postage stamp (right).



A copy of the petroglyph, as seen in the photograph above.

which lasted approximately six hours, the Moon was situated in the constellation of Gemini.

The central portion shows a little man expressing gratitude to his God for witnessing this lunar eclipse after travelling halfway around the world. Situated behind the little man is a drawing of a water clock (see also illustration) set up on a stand to record the interval of time between Local Mean Time of noon and the time of the lunar eclipse. This would enable a direct calculation of the longitude of the observer.

The stick-like animal to the left of the little man could represent his logo, a bird. According to Barry Fell, travellers were known as "the People of Manu." The word "Manu" is very common throughout the peoples of the Pacific and translates as "animal," or more generally, "bird."

The Explanation

A copy of Egyptian hieroglyphics from the Tomb of Osiris shows the extensive use of the five-pointed star. This is a reference to "ruling monarch," whose name would be attached.

The Greek occupation of Egypt, which started with Alexander the Great in 323 B.C., was a time of great wealth and culture. During the reigns of Ptolemy II and III, the Library of Alexandria, under the leadership of Eratosthenes, became the center of learning for the Mediterranean region. Major advancements were made in the knowledge of all sciences, astronomy in particular.

Ptolemy III Euergertes came to the throne in 247 B.C., and reigned jointly with his father, Ptolemy II Philadelphus, until his father's death in 245 B.C. The start of the Egyptian New Year, on the first of Thoth (Oct. 23, 247 B.C.) would have recorded the start of Ptolemy III's second regnal year. The lunar eclipse observed at Pitcairn Island on Dec. 14, 233 B.C., would therefore have occurred in his 16th regnal year.

History shows that the ancient Greeks

CLEPSYDRA, OR WATER CLOCK

A water clock, known to the Greeks as "Clepsydra, the Water Stealer." In this water clock, a central, tapered pot leaks water at a regular rate. A pot with parallel sides leaks more slowly as the water level drops, and the Egyptians overcame this by tapering the sides of the pot inwards by 70°.

Source: A. Pavel and F. Honzak, *Living in the Past*. London: Hamlin, 1988

Note the repeated use of the five pointed star, symbol for "ruling monarch," in these hieroglyphics from the Tomb of Osiris in Egypt.

LUNAR ECLIPSES OCCURRING 234 B.C. TO 230 B.C.

Lunar eclipse on Dec. 26, 234 B.C. Overhead at

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	−21	18	25	68	+87	+20
Moon enters umbra	−22	30	9	58	+70	+20
Total eclipse starts	0	1	1	187	+48	+20
Maximum eclipse	0	12	8	—	+45	+20
Total eclipse ends	0	23	12	62	+42	+20
Moon leaves umbra	1	54	5	291	+20	+20
Moon leaves penumbra	3	6	2	281	+ 3	+20

Magnitude of umbral eclipse = 1.018

Lunar eclipse on June 20, 233 B.C.

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	17	26	7	104	+148	−21
Moon enters umbra	18	28	43	107	+133	−21
Total eclipse starts	19	30	44	297	+118	−21
Maximum eclipse	20	19	43	—	+106	−21
Total eclipse ends	21	8	45	79	+ 94	−21
Moon leaves umbra	22	10	49	269	+ 79	−21
Moon leaves penumbra	23	13	20	272	+ 64	−20

Magnitude of umbral eclipse = 1.575

Lunar eclipse on Dec. 14, 233 B.C.

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	6	25	33	90	−46	+23
Moon enters umbra	7	26	36	95	−61	+23
Total eclipse starts	8	30	2	295	−76	+23
Maximum eclipse	9	11	16	—	−86	+23
Total eclipse ends	9	52	30	45	−96	+22
Moon leaves umbra	10	55	57	245	−111	+22
Moon leaves penumbra	11	57	13	250	−126	+22

Magnitude of umbral eclipse = 1.369

Lunar eclipse on June 10, 232 B.C.

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	−23	17	4	79	+55	−25
Moon enters umbra	0	37	5	63	+36	−25
Maximum eclipse	2	7	14	—	+14	−25
Moon leaves umbra	3	37	28	322	− 8	−25
Moon leaves penumbra	4	57	27	306	−27	−25

Magnitude of umbral eclipse = 0.665

Lunar eclipse on Dec. 4, 232 B.C.

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	−21	27	57	111	+92	+25
Moon enters umbra	−22	52	16	140	+72	+25
Maximum eclipse	−23	38	20	—	+61	+25
Moon leaves umbra	0	24	22	191	+50	+25
Moon leaves penumbra	1	48	50	219	+29	+25

Magnitude of umbral eclipse = 0.188

These data were prepared by Dave Herald, Canberra, Australia. U.T. is universal time. Note that the penumbral eclipses would be barely noticeable.

Ptolemy III Euergetes, as depicted on a gold coin of Alexandria, after his death. The trident of the sea god Poseidon is at his shoulder. Ptolemy III was king at the time of the exploratory voyage of Maui and Rata, across the Pacific in 232 B.C.

Source: 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

were familiar with eclipses in general, and lunar eclipses in particular. Thales, who is credited with predicting the first solar eclipse in 585 B.C., was aware that the Sun, Moon, and Earth returned to their same relative positions after a period of 18 years, 11 days—the so-called Saros Cycle. It was recognized in ancient times that an eclipse of the Moon offered a method to determine longitude by being an accurate clock, visible from many parts of the Earth. The exact time that the Earth's shadow comes onto the disk of the Moon is independent of where the event is observed.

An early Greek attempt of this technique, compared the reported timing of the eclipse of Sept. 20, 331 B.C., made in Carthage (in modern Tunisia) and Arbela in the Middle East. The different times read on the clocks when the eclipse began were taken to indicate the difference in longitude of the two cities.

The astronomical representation of the constellation Gemini, as seen in the Northern Hemisphere, is shown at left, p. 58. The two brightest stars in this constellation, α and β, also called Castor and Pollux (the Dioskouroi) were the savior gods of the Greek seafarers.

The drawing on the right, p. 58, shows the Southern Hemisphere's northeastern sky for the month of December. This would have been the sky as observed from Pitcairn on the night of the eclipse, with the full Moon rising with the constellation of Gemini.

The lunar eclipse, which occurred on December 14, 233 B.C., would have been overhead in the mid-Atlantic at 6:25 Universal Time. The Moon then passed over the Bahamas and obtained maximum eclipse over the Gulf of Mexico at 9:11 Universal Time, before terminating over the Western Pacific, off the coast of California at 11:57 Universal Time.

On Pitcairn Island, situated at longitude 130° West, the Moon would have been clearly visible in the northeastern

Lunar eclipse on April 30, 231 B.C.

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	11	11	34	179	–127	–25
Maximum eclipse	12	34	25	—	–147	–25
Moon leaves penumbra	13	57	8	232	–167	–26

Magnitude of penumbral eclipse = 0.305

Lunar eclipse on May 30, 231 B.C.

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	1	27	3	45	+20	–27
Maximum eclipse	2	56	15	—	– 1	–27
Moon leaves penumbra	4	25	25	348	–23	–27

Magnitude of penumbral eclipse = 0.346

Lunar eclipse on Oct. 25, 231 B.C.

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	1	20	25	17	+26	+26
Maximum eclipse	3	17	8	—	– 2	+26
Moon leaves penumbra	5	14	3	290	–30	+27

Magnitude of penumbral eclipse = 0.802

Lunar eclipse on April 19, 230 B.C.

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	15	59	38	140	+163	–25
Moon enters umbra	17	10	15	154	+146	–25
Maximum eclipse	18	39	52	—	+124	–25
Moon leaves umbra	20	9	24	260	+102	–26
Moon leaves penumbra	21	20	15	275	+ 85	–26

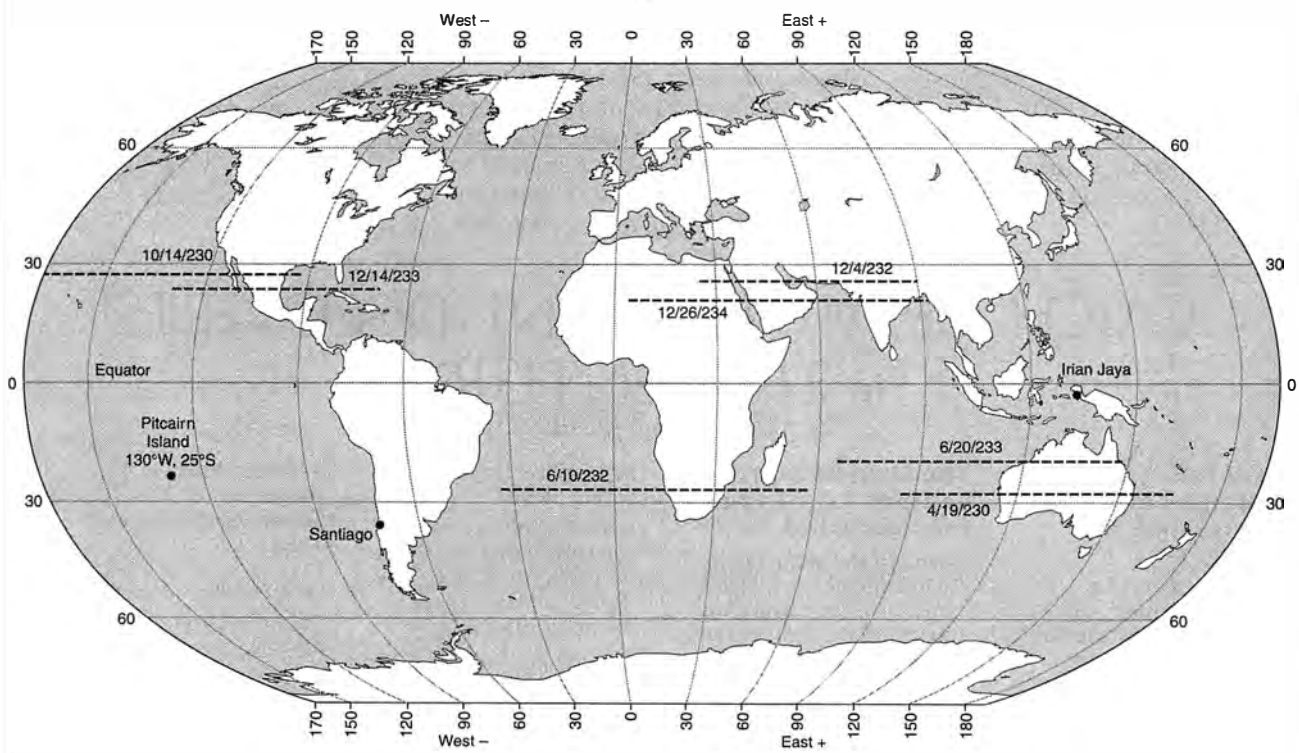
Magnitude of umbral eclipse = 0.742

Lunar eclipse on Oct. 14, 230 B.C.

Event	U.T. h	m	s	P.A. °	Long. °	Lat. °
Moon enters penumbra	8	59	56	44	– 95	+24
Moon enters umbra	10	12	53	33	–113	+24
Maximum eclipse	11	53	23	—	–137	+24
Moon leaves umbra	13	34	1	270	–161	+25
Moon leaves penumbra	14	46	53	259	–179	+25

Magnitude of umbral eclipse = 0.964

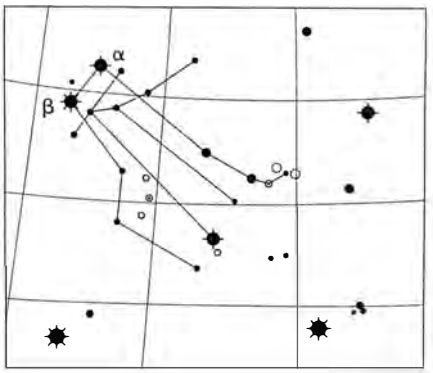
These data were prepared by Dave Herald, Canberra, Australia. U.T. is universal time. Note that the penumbral eclipses would be barely noticeable.



SCHEMATIC OF FULL LUNAR ECLIPSES, 234 B.C. TO 230 B.C.

sky on the evening of Dec. 13, 233 B.C. The Moon would have entered the penumbra at 21:45 Local Mean Time, soon after rising above the horizon. Maximum eclipse would have occurred at 03:12 hours Local Mean Time on Dec. 14, 233 B.C., with the Moon leaving the penumbra at 03:17 Local Mean Time.

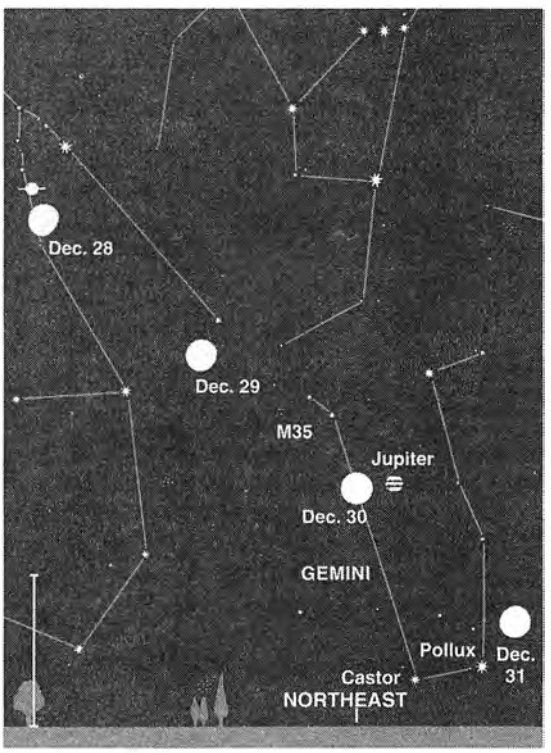
Between Jan. 5, 234 B.C. and Dec. 3, 232 B.C., seven lunar eclipses occurred around the world at regular six-month intervals. The Greeks, having recorded these eclipses on previous occasions and being aware of the regular Saros Cycle, knew in advance when these eclipses would



The constellation Gemini. Its two brightest stars, Castor (α) and Pollux (β), were the savior gods of seafarers in Ancient Greece.

recur. It is therefore highly possible that an expedition was organized to traverse across and map the Pacific Ocean, using predetermined lunar eclipses to establish longitude.

Barry Fell described the drawings on an eclipse recorded in a cave at Irian Jaya in the 15th Regnal Year.[2] This would have been the lunar eclipse on Dec. 26, 234 B.C., which would have been visible at both Irian Jaya and Egypt. Pitcairn was recorded on Dec. 14, 233 B.C., and it is possible that the last eclipse was recorded at Santiago on June 10, 232 B.C.



THE EVENING SKY AS SEEN FROM PITCAIRN ISLAND, DECEMBER 28-31, 233 B.C. *This illustration shows the Moon as it passes through the constellation Gemini during the month of December, as it could have been seen from Pitcairn Island in the Southern Hemisphere, looking northeast.*

Ross Perfect, Licensed Surveyor with New Zealand, Fijian and Australian Qualifications, now lives in Queensland, Australia, and has spent considerable time in the South Pacific. He was inspired by the biography of Barry Fell to pursue this analysis of the Pitcairn Island petroglyphs.

Notes

1. See Appendix 1, *Epigraphic Society Occasional Publications*, Vol. 2, No. 21 (1975). Part 1 of the biography of Barry Fell, by his son Julian Fell, appears in the Winter 1999-2000 issue of *21st Century*, "Barry Fell, Epigrapher: Biography of a Renaissance Man," pp. 40-63. Part 2 appears in the Summer 2001 *21st Century*.
2. *Ibid.*

INTERVIEW WITH ASTRONAUT ANDY THOMAS

It's Time for Australia To Get Into Space!

Australian-born astronaut Andy Thomas has made two flights on the Space Shuttle, and spent 130 days on the Russian Mir Space Station. A Ph.D. in mechanical engineering from the University of Adelaide, Dr. Thomas has given many public lectures in Australia, and is an outspoken advocate for Australia to join the international community in its manned space programs.

Dr. Thomas was interviewed by Marsha Freeman on Nov. 7, 2001.

NASA

Astronaut Andy Thomas: "The reception from the people I talk to, the man in the street, as well as educated lay persons, has been extremely positive about human space flight."

Question: You testified last summer before the International Space Advisory Group, on Australia's future in space. What were your recommendations?

My role was to give them some ideas, particularly about possible involvement in the International Space Station. We were talking about a potential landing site for the X-38 vehicle, and a landing site for a crew return vehicle for the Space Station, should it evolve from the experimental X-38. Because Australia is a big, wide open space that is easy to hit with a crew-return vehicle, it is very attractive for a landing site.

Question: Which areas of Australia would be considered appropriate for such a landing site?

There are actually a number of possible landing sites, but the most probable is a test range in the northern part of south Australia called Woomera. I think it would certainly be very much in the Australian Government's interest to do that, to support the infrastructure, because it is a very unique test range.

Question: There would seem to be many ways that Australia could contribute to the International Space Station. Australia already has a large program in Earth remote sensing. Could that area be a possibility?

That was one of the things I also suggested, as an area where Australia could do something with the Space Station and provide a capability that would be unique for Australia, sensing of geography of the land, sensing of the surrounding oceans, for ecological and resource management, and environmental management. The question you have to address is, are you best off doing that on a Space Station, on a human-tended vehicle, or on a free-flyer?

The conventional answer is that a free-flyer is the best way to go, but I made the point that that doesn't account for the fact that if you do it on a Space Station, you have a person in the loop who can make real-time decisions, you can modify your instrument, you can fix your instrument if there is a problem with it, and you can bring your instrument back to the ground and refurbish it.

If Australia was to do it, it would have a device that would be applicable not just to Australia, and it would be able to do collaborative ventures with other countries, to use the same data sources that they generate.

Question: Beside remote sensing, what other areas could Australia participate in?

In all of the areas of research that go on on the Space Station—life sciences, microgravity science, and basic physics—Australia has the educational capacity to contribute to *any* of these.

Life sciences is one field that comes to mind. Australia has a very strong medical community, and there is a lot of interest in the medical issues faced in long-duration spaceflight as they apply to people on the ground.

In microgravity sciences there are the basic skills in the universities. There are the skills in basic physics, in remote sensing. In any of those areas, Australia could do collaborative science, and I made a big push for them to do that. I think it would be very much in the country's best interest because you leverage the resources and start getting a community of educated people building up in the society.

You develop very unique, advanced skills. They may not stay in the space program, but those skills diffuse into the community and after 10 years you start to see them paying dividends in other areas, in other innovative technologies, start-up companies, and venture funds. That's where the big payoff would be for Australia, aside from the fact that doing these things enriches the community in its own right. People find it exciting, and that's enough justification in its own right to do it.

NASA

Andy Thomas has proposed that Australia provide a landing site for the Crew Return Vehicle (CRV), that will be developed for the International Space Station. Seen here is the NASA X-38 test vehicle, the precursor to the CRV.

Question: It would seem that Australia could also develop modest pieces of hardware for the Space Station, as any even small involvement is a foot in the door into this international effort.

I suggested developing flight hardware of some kind to support the Space Station. I don't think Australia is fiscally in a position to develop a module. However, it could easily develop components of modules for another agency, such as the European Space Agency or the Canadians. There are a lot of collaborative opportunities, where Australia has the technology skills to do it.

When I suggest that, the question I get is, "Why should Australia develop something to support a Space Station module? What does Australia get out of it?"

Australia would actually get a lot. If Australia developed a life support system for a space station module, Australia would get all that technology, which has applications, for example, to submarines. Well, Australia is building a fleet of submarines for itself, and that life support technology has immediate application there. It also has application in the refurbishment and maintenance of commercial aircraft, which is a big business in Australia. Many airlines go there to do it because it's attractive, financially.

If Australia provided communications systems for a station module, that would also have applications to systems for military vehicles, as well as commercial vehicles on the ground.

If Australia had a full-time support capability for an emergency landing site for the Space Station crew return vehicle, which is another option, Australia would require search and rescue capability and special medical vehicles, to be deployed in the event of an emergency on the space station.

But those resources would be available to Australia in times of national need. It would not be something sitting there gathering dust; it could be functioning, supporting the communities in the remote areas of Australia, at the same time that it is on call to support the Space Station.

That's the approach that I took in my briefing. I said that all of these things are not something that is done in isolation, just to support the space program. They all have application to the needs of the country. In that sense, you are enriching the capabilities of the country by doing these things because you are gaining access to the technologies and capabilities that you would not otherwise have.

Question: Is it correct that at this point, there is no Australian space office, or agency comparable to NASA?

That is correct. I made a push for that. I thought that with the various activities that Australia could participate in, either through the International Space Station or through the Woomera test range, or the work going on at Christmas Island [launch site], that Australia did need to have a focussed, centralized space office which would report to a cabinet minister at a high level, and have a clearly defined mandate and budget and goals.

That would avoid some of the turf battles you get when you have multiple organizations trying to do things. You'd have someone clearly in charge, and I think that is very important.

Question: Why has it been so difficult to establish a centralized space agency?

There have been attempts to do that in the past, but space and those really long-term investments in research are not part of the Australian culture. Traditionally, Australia doesn't do that. It funds more near-term things.

Australia has had, in fairness to the political leaders, some economic problems that required pretty immediate action, so there haven't been the resources to do this. I am of the opinion that the world is changing and the 21st Century will be a world of very sophisticated technologies; and certainly remote sensing has suddenly taken on a whole new importance since September 11.

I think you have to look and see what will be the values of the 21st Century world. They're going to be in high technology systems, research and development, of which one element is space-based activities. I think if any country is going to be a player on the world stage, and therefore, an active player in the world economy, then that country needs to embrace those values. That is something Australian political leaders need to do.

Question: There is, very often, a disconnect between the political leadership of a country and the kinds of programs that would be supported by the citizens of that country. What kind of response do you get when you give talks about space in Australia?

I've generally found that the reception from the people I talk to, the man in the street, so to speak, as well as educated

lay persons, has been extremely positive about human space flight and being inolved. There's great excitement there. For young people, of course, that's undeniably true, but it's not just young people, it's also the people at large. I think some of that has been picked up on by the political leaders, too.

I had the great privilege to address the Australian Federal Cabinet in July—this is made up of the various ministers who report to the Prime Minister. That was a great honor. I briefied them about the Space Station and about Australia's unique capabilities by virtue of its geography, which includes Christmas Island and Woomera, and I made a big push for Australia to get involved in these activities, because I think there will be a significant economic benefit to the country in years to come.

It won't be a near-term economic gain; these things never are, they are a long-term economic gain. But I think Australia is well positioned to be a participant in those because it has a good technology infrastructure, it has a good education system, it has a good R&D base, it's very stable politically, and it is an English-speaking country. These are all definite advantages, and pluses in why Australia should get involved in some of these things.

Question: One would think that there is great interest in manned space programs in Australia, because it has two astronauts who have flown in space.

That needs to be clarified a bit. The two of us got our start in Australia, but we do not represent Australia in any way.

Paul Scully-Power was a payload specialist as an oceanographer. In fact, he was not an astronaut. He was an oceanographer who did not represent Australia, but flew as a U.S. citizen. I flew as a U.S. citizen on my first flight. I subsequently had my Australian citizenship reactivated, because they changed the laws there, so I also do fly as an Australian citizen, but I don't represent Australia formally. It's an informal representation by virtue of my heritage.

That's a point I make when I'm in Australia, because a lot of people say: "Why should we get involved in space? We've had Andy Thomas as an astronaut, we've gotten an Australian citizen into space, we've had Scully-Power as a payload specialist. What more should we do?"

The fact of the matter is that none of these was formally linked with Australia. Australia does not have a formal role in human space flight.

Question: To accomplish the kinds of goals you are recommending for Australia, there would have to be a government policy to do so. Would that be part of a larger orientation of the government towards research and development programs?

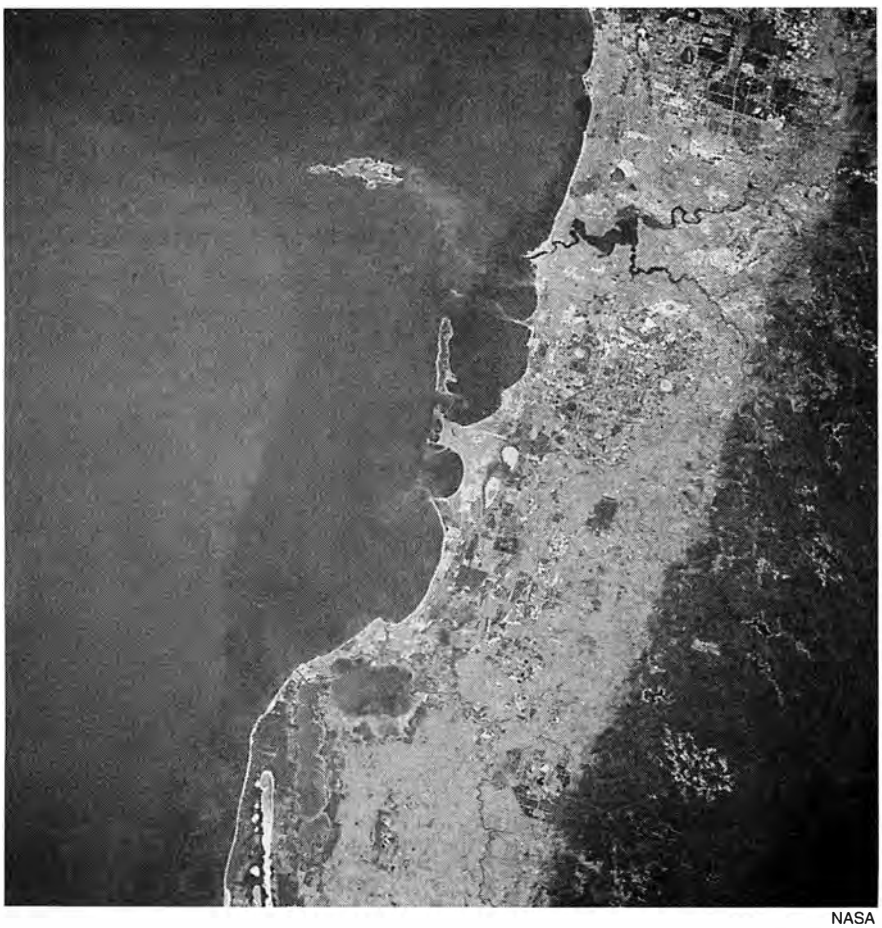
That is the big issue. The big push I've tried to make is to get the government to think about these kinds of activities, that are really part of a bigger research, development, and technology plan that I think governments do need to follow through with. You have to make an investment in the future, in research and development. You have to make an investment for your grandchildren.

You can't run an economy just looking at what is going to be the return in the next election cycle, because some things take longer to develop than that.

If the United States had worked on just trying to get a return before the next election, we would not have all the computers and the Internet, and all the capabilities we have, because they have taken many, many years to develop. They take a stable policy of research and development that is bipartisan in support, and is agreed upon by everyone as being in the country's national interest.

Question: One very important long-term benefit from investment in research and development, and space exploration, in particular, is in advancing the quality of education in society.

That's true, and if you look at what NASA has done over many years, NASA spending has made a huge contribution within the university system of this country. It's just huge.



NASA

One of the contributions that Australia can make in space technology is in the field of Earth remote sensing. Here, a space image of the Perth area in Western Australia, taken in 1998.

An unbelievable amount of the work that goes on in flying the Shuttle, in developing the payloads and the systems, believe it or not, is done by graduate students earning their degrees. Those graduate students may not stay in the space program, but they get a specialized skill which they take out into the community, and that enriches the community in other areas.

That was one of the pushes I made with the Australian government, that if you do these things, you put value-added into the community which, I think, is impossible to quantify, but is profound. You change the nature of your society in a very positive way for the next 20 years. That's the intangible part.

It's a very hard sell to political leaders because they have to justify the return to their constituency, and it's hard when people are unemployed, and so on, to get them to think that they need to worry about the legacy they are going to leave for their grandchildren.

When I briefed the Federal Cabinet about the Space Station, they were of the opinion they could only be involved in it if they committed hundreds of millions of dollars. That's true, if you want be a full-up active partner.

However, you don't have to do that. You can be a participant in the science programs, by just spending some millions of dollars in research and development programs that would, for example, be done collaboratively with investigators here. By doing that, you access all the other research and development that's going, so you leverage your small investment. You get a lot more for it than you might otherwise.

Question: When you discuss Australian participation in the International Space Station, does anyone bring up the fact that Brazil is making a significant contribution to the Space Station program?

I bring that up all the time. I use Brazil as an example. I point out, as I've done with the Prime Minister's Chief Scientist, that Brazil is spending money on the Space Station and has got an astronaut here [at NASA's Johnson Space Center in Houston].

They are trying to show the world that they have these capabilities, and that they are a player on the world stage. They want countries to come to them to launch vehicles, because they have a geography that's ideally suited for launching vehicles. By being a player in this activity, they are bringing that business, potentially, into their country.

I make the point that Australia is exactly the same. It has the same kind of geography for launch vehicles, and it would be very much in Australia's interest to follow the Brazilian paradigm and start getting involved.

I think there's a large school of thought there that this is a valid message.

This year is an election year [in Australia]. I think neither of the political parties was willing to step up to this kind of high-risk vision, during an election campaign. However, I'm hoping that after the election campaign we will see steps in this direction.

A thrust for both political parties for this election has been on improving education and research and development. I think it is generally being recognized that Australia has languished in those areas in the last 20-odd years, that the quality of education in universities has fallen, and there is no doubt that it has, unfortunately.

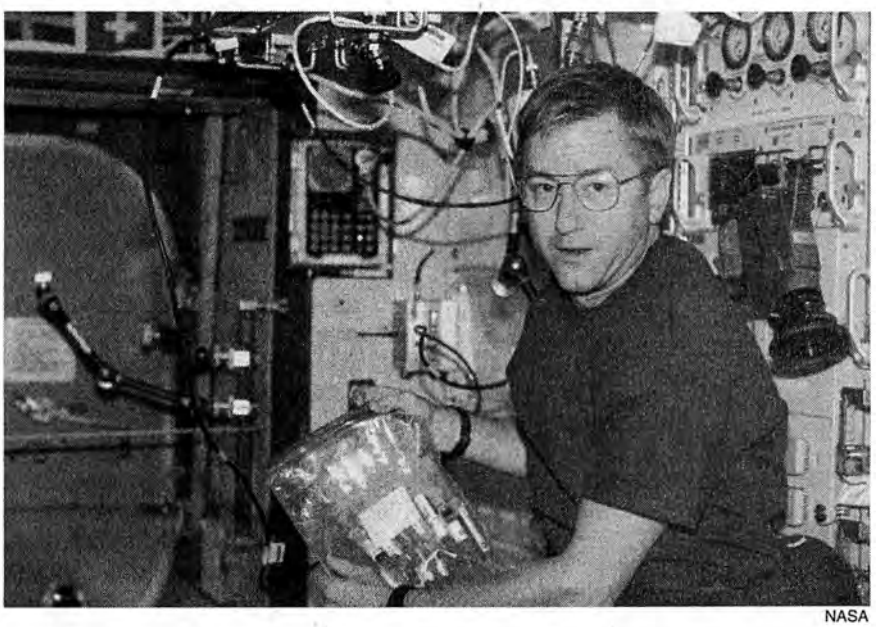
Class size is larger, teaching loads have become larger, pupil-teacher ratios have gone up, with fewer and fewer teachers in universities. It is generally recognized that Australia is paying a price for this, by virtue of the fact that right now the Australian dollar is about 51 U.S. cents. It was nearly on a par with the U.S. dollar 20 years ago.

To a very large extent Australia's economy—which is a service economy, it serves the economies of the rest of the world—does not do a lot of value-added in its own right. When you don't have research, and you don't have education, that's the inevitable outcome. You have a 50-cent-on-the-dollar economy.

If you want to change that, you're not going to do that overnight with some political policy. It's going to take a huge shift in the values of the society, and the promotion of innovation. The way you do that is through education and research and development.

Question: There are certainly many avenues Australia can take to participate in the Space Station. What pathway would you recommend?

I think Australia could get to the point where it flies an experiment on the Space Station. I don't think it would be right to just spend hundreds of millions of dollars. The plans I've proposed to the chief defense scientist were to move cautiously on this.



NASA

Astronaut Frank Culbertson, Commander of the third Expedition Mission aboard the International Space Station, holding a syringe kit, used to grow tissue in NASA's biotechnology program, in a photograph taken on Aug. 29, 2001. Australia, Andy Thomas states, could contribute to every area of research on the Space Station.

Start with a modest investment in research and development and some collaborative science. Slowly build up that capability. Start developing, perhaps, flight hardware as a collaborative venture with the major [space] agencies, to develop your credibility and capability, and then slowly build up to the point where you can build flight hardware that specifically serves Australia's needs, and can be funded at a level that is appropriate for Australia. That's the way you do it.

Question: There is under way a tremendous economic reorientation throughout Asia as a whole, which Australia must become involved in. A series of very large infrastructure projects, including the building of new rail connections to form a Eurasian Land-Bridge, creating development corridors throughout Asia. Over the last year, many Asian countries have realized that their dependence upon the United States to import their goods is on shaky ground.

These countries are looking at what large-scale infrastructure projects must be implemented, and Australia is sitting nearby with industrial and other capabilities.

I agree with that. I think that's the big cultural shift that Australia is facing, and has been facing over the last 20 years or so, which is to come to recognize that Australia is, in fact, part of the Pacific nations. Australia traditionally was part of the British Commonwealth, but really Australia's role in the world today doesn't lie with Europe or even, for that matter, with the United States.

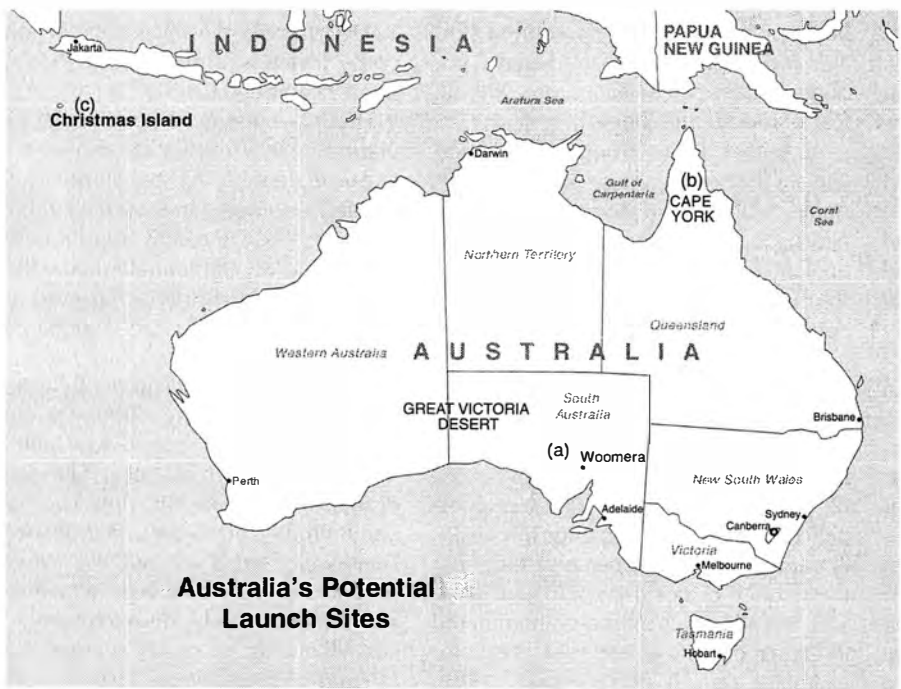
NASA

Andy Thomas trying on his Russian space suit inside a Russian Soyuz in January 1998, in preparation for his 130-day stay on the Mir.

It's going to lie primarily with Southeast Asia, and especially Indonesia, and that's the big cultural paradigm that is changing in Australia. I think that's all the more reason why Australia should be involved in these space activities, because those nations are going to be looking for representation in human spaceflight and in launch capability.

Question: What do you see for Australia in space, farther in the future?

There is going to be a great human adventure of the 21st Century, and that is going to be a trip to Mars. It's probably not realistic to have an Australian crew person fly on that mission, unless there was a huge investment, which probably is not viable. But Australia could certainly develop some of the hardware for that mission and when that mission goes, just imagine how excited the people of Australia would be to say: "That mission is happening because we've got this device that we built. We actually contributed to that mission."



Australia's Potential Launch Sites

Australia has promising sites to be developed for the launch of commercial satellites. The Woomera test range (a), which dates back to the end of World War II, is ideally suited for testing launch vehicles, which can fly northwest over 2,000 kilometers of virtually uninhabited land, and to put satellites into a polar orbit, launching toward the north.

Cape York (b), near the equator, could accommodate satellites that would travel east, on their way to geosynchronous orbit. And Christmas Island (c) is under consideration for joint development through the Asia Pacific Space Center, which would launch the Russian Aurora rocket.

Food Irradiation Technology Can Kill Anthrax

by Marjorie Mazel Hecht

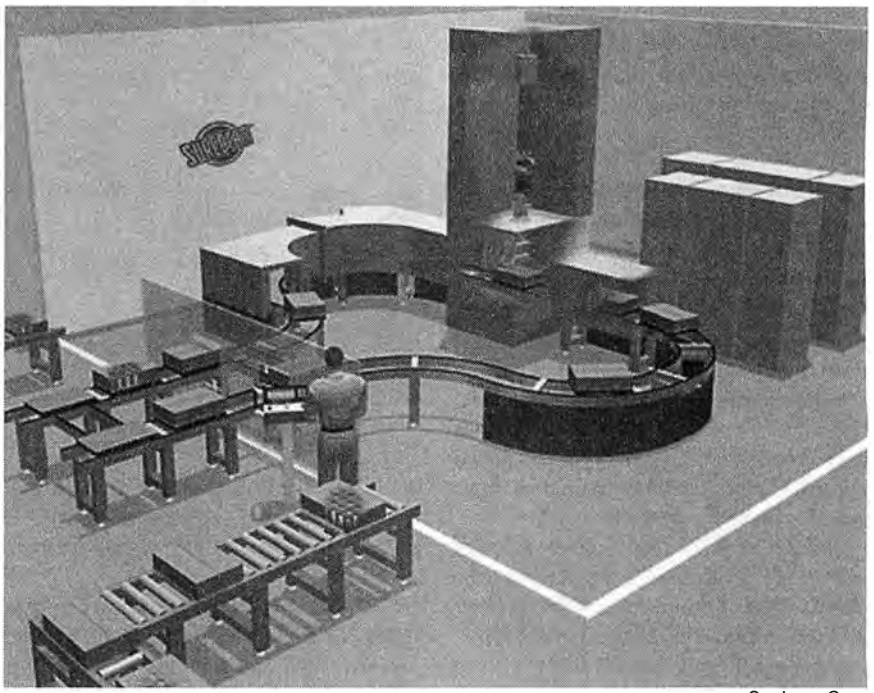
Food irradiation technology, which uses ionizing radiation to kill bacteria, mold, fungi, and viruses on foodstuffs, will also safely kill anthrax bacteria on mail. The U.S. Postal Service is now decontaminating some Washington, D.C. mail at an electron-beam irradiation plant in Lima, Ohio, and the government has ordered eight electron-beam irradiators from SureBeam, a San Diego-based company affiliated with the Titan Corporation, at a cost of approximately $26 million.

SureBeam now operates two food irradiation plants, one in Des Moines, Iowa and the other in Chicago, both geared to processing chopped meat, and a third plant is expected to open in the Los Angeles area.

Ionizing radiation, produced by an electron beam accelerator or by a radioactive source like cobalt-60 or cesium-137, is a "cold" process that penetrates the cell of a bacterium—salmonella, E. coli, camphylobacter, anthrax, or other harmful microorganisms. There is *no* radioactive residue left in the product, and the product is not heated.

The electron beam accelerator can also be used to produce X-rays for irradiation. These very short, very energetic rays penetrate solid particles and kill microorganisms by breaking down the cell walls or destroying the metabolic pathways (DNA) of the organism so the cells die. Foods are processed inside sealed packages, to prevent any new contamination.

At low levels, ionizing radiation can delay sprouting in potatoes and onions, lengthen the shelf-life of fruits and vegetables, or ensure that meats, poultry, fish, or spices are 99+-percent pathogen-free. The irradiation causes virtually no changes in taste, texture, aroma, or wholesomeness of the food. In fact, the fruits and vegetables are often superior in taste, because they can be allowed to ripen on the vine before being irradiated and shipped, instead of being picked green to ripen during storage and shipping. And irradiated hamburger patties can be eaten *rare,* without fear of food-borne illness.



Surebeam Corp.

Artist's illustration of an electron-beam irradiation facility. The containerized product travels on a conveyor belt through the e-beam device.

At higher levels, ionizing radiation can sterilize foodstuffs so they are shelf-stable, without refrigeration. The astronauts ate irradiation-sterilized foods to prevent food-borne illness; irradiation-sterilized food is available for immune-compromised patients.

50 Years of Research

Although food irradiation technology has been in development for 50 years, its commercialization was slow, until the last decade, when highly publicized deaths from food-borne illnesses compelled more large companies to consider use of irradiation, because they fear the liability of *not* using it. There were 129 recalls of bacteria-contaminated foods nationwide in the year 2000, for example, up 37 percent from 1999. According to U.S. government data, 10,000 people die each year of food-borne illnesses, and hundreds of thousands become ill.

There are about 50 commercial irradiation plants operating in the U.S., most of them using cobalt-60 as the radiation source, and most sterilizing not food, but medical supplies. The facilities to decontaminate mail will be separate from existing facilities, to prevent any chance of cross-contamination.

In the early 1990s, spurred by visionary entrepreneur Sam Whitney, a commercial irradiation plant was built in Mulberry, Fla., to aid local farmers in disinfesting strawberry crops. The company, Vindicator, came under attack by some well-funded anti-nuclear activists, but the company survived, market tests of irradiated strawberries were very successful, and the company operates today as Food Technology, Inc.

In the last two years, Titan Corp., a

defense contractor, has launched a campaign for food irradiation using electron beam accelerators and calling the process "cold pasteurization." SureBeam, a Titan subsidiary, now has contracts with major suppliers of meat, poultry, cold cuts, and other products, as well as the Department of Defense. (Diarrhea caused by food-borne microorganisms is a common health problem for troops, especially in tropical countries.)

Irradiation is now approved for use on a wide variety of products in about 40 countries. In November 2001, the U.S. Defense Department announced that had added irradiated ground beef and poultry products to its military food procurement authorization. Estimates are that 25 percent of food produced in industrialized countries, and 40 to 60 percent of food produced in developing countries, spoils or is eaten by insects or rodents, before it can be eaten by human beings. As part of the 1950s Atoms for Peace project under President Eisenhower, it was assumed that irradiation plants in developing nations would help feed growing populations—until the shift to a post-industrial society and its anti-population, anti-nuclear ideology stifled the technology's development.

Although the United States pioneered the technology, it is only recently that U.S. consumers have been able to reap the benefits: Irradiated hamburger patties, chicken, and some fruits are available in many supermarkets across the country. Ironically, Americans have learned more about the benefits of irradiation in the past month, because of the anthrax threat, than in the past 50 years!

How It Works

Each method of irradiation has its advantages. Gamma rays can penetrate produce to a depth of 30 inches, irradiating the product on one side only. Usually, the produce will be packaged, boxed, and stacked on pallets which ride a conveyor belt that goes around the radiation source, to get even penetration throughout the pallet load. The dose and time of exposure have been calculated for all kinds of products, and to be sure the radiation reaches all parts of the pallet contents.

The electron beam (10 MeV) uses no radioactive source, just electricity to turn the accelerator on. Electrons are produced, contained by a magnetic field, and accelerated into a narrow beam. The e-beam penetrates only about one and three-eighths of an inch, passing through water or something of equivalent density. If the product is irradiated from both sides, the beam would penetrate two and three-quarter inches or so—about the depth of eight hamburger patties. Again, the boxed product is moved on a conveyor belt through the electron beam.

X-rays are made from deflecting an electron beam on a heavy metal target, like tungsten. The target has to be thin enough so the electrons will give up their energy, which is converted into X-rays. These can go several feet, but their production requires more electrical power, and so is costlier than electron-beam or gamma-ray irradiation. A new plant in Hawaii uses X-rays to process papaya and other tropical fruits, which cannot be shipped to the mainland unless they have some form of approved disinfestation.

Mail is not food, and killing weaponized anthrax requires a higher dose of irradiation, more than 40 kilogray (kGy). The exact dose and procedure is not being made public, Surebeam spokesman Wil Williams told *21st Century,* to prevent such information from aiding the anthrax perpetrator. Existing studies have shown that the antrax bacillus is inactivated at 41.5 kGy. During the 1960s, Australia successfully used irradiation to destroy anthrax spores in imported goat hair that was used in making carpets.

Now, new protocols have to be worked out to ensure that workers are protected, and that the final product is decontaminated without allowing any cross-contamination. The problem is a daunting one, but the nation has faced serious threats in the past, and won (the Manhattan Project of World War II comes to mind). Food irradiation technology must be part of any national defense program against bioterrorism, as well as protecting Americans from food-borne illness.

More Lies from the Anti-nukes

The same groups that have attacked food irradiation jumped into action soon after the Post Office announced that it would use irradiation to kill anthrax spores. Public Citizen issued a release on "Anthrax and Surebeam" Oct. 18, with no scientific basis, stating that "radiation is ineffective against anthrax spores."

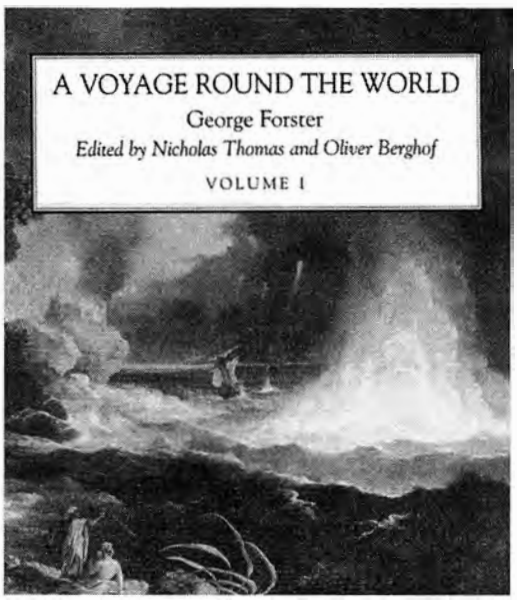
Further, the Public Citizen release states: "Given the level of fear that has gripped the nation, unsubstantiated claims about a technology's ability to kill anthrax are irresponsible and dangerous. Claims of this magnitude should be supported by peer-reviewed scientific research."

Imagine what might happen if Public Citizen applied such wisdom to any of its own fear-promoting "claims" about advanced technologies.

The Suppressed Story of Captain Cook's Second Voyage

by Rick and Lenore Sanders

A Voyage Round the World
George Forster
Eds. Nicholas Thomas and Oliver Berghof
Honolulu: University of Hawai'i Press, 1999
Hardcover, 860 pp., $115.00

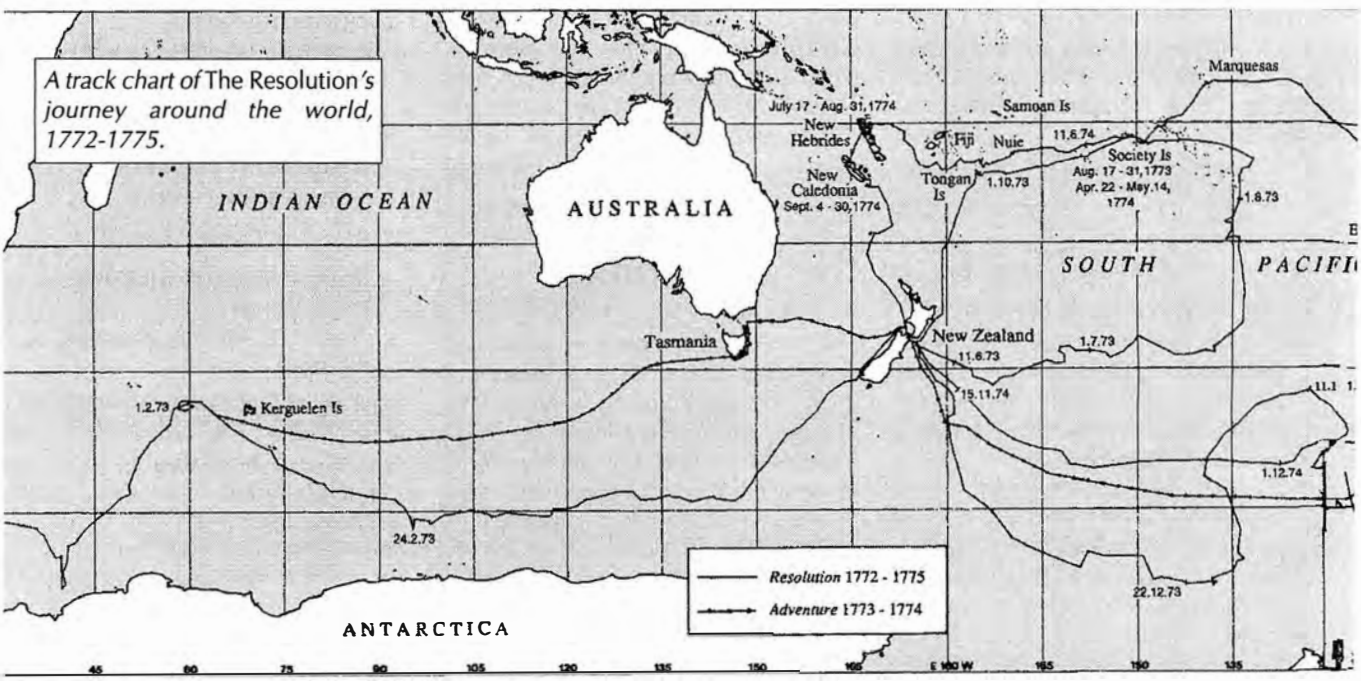


A *Voyage Round the World* is a wonderful book, which was suppressed when it was first written in 1777. A documentation, in narrative form, of the sometimes harrowing adventures aboard Captain Cook's second voyage, it gives not only the navigational trials of the voyage, but also a naturalist's descriptive chronicle of indigenous plants and animals, of oceanic, terrestrial, and atmospheric characteristics, and, what is more, a truthful humanistic anthropology of the peoples of the South Sea islands and of British-European social structures and behaviors. The University of Hawai'i Press must be gratefully congratulated for publishing this book, which also includes the most important documentation of the controversy which surrounded it, and many illustrations from the journey.

The author, Georg (George) Forster, was the eldest of the seven surviving children of Johann Reinhold Forster (1729-1798), a Protestant minister and a naturalist. Financially, the family was quite impoverished.

In 1765, when Georg was only 11 years old, he accompanied his father on a trip to Russia, commissioned by the Russian government, to inspect the settlements of German colonists near the river Volga. It was a journey of about 4,000 kilometers, in the course of which the Forsters described a large number of new animal and plant species. But when Johann Reinhold Forster's humanity would not permit him to keep silent about the lawlessness, enslavement, and harsh living conditions in the region, his Russian patrons withdrew their support, and father and son took leave for England, where they were living when this adventure begins.

The Forsters accompanied Captain Cook on his second voyage aboard the *Resolution* (July 13, 1772 to July 30, 1775), which was commissioned to continue the drive toward the South Pole, to once and for all establish whether or not a southern continent



existed. Johann Reinhold Forster was called upon to serve as the ship's naturalist, after the hostile indifference of the First Lord Commissioner of the Board of the Admiralty, the Earl of Sandwich, had caused the withdrawal of Joseph Banks, the naturalist who had accompanied Cook on his first voyage.

Johann Reinhold was promised that, upon his return: he would receive maintenance sufficient for the care of his large family; that he was to be employed to write the narrative history of the voyage; that the engravings reproduced from the drawings made during the journey would belong jointly to Forster and to Cook, and; that they would be printed with Forster's written history. He was promised the profits from the sale of the narrative.

All such promises were broken, and Johann was prohibited from writing the account. When his son Georg, therefore, who was not encumbered by the injustice of contrived legalities, wrote *A Voyage Round the World,* the Forsters and this fine book were so viciously slandered that the book simply did not sell in England. In the midst of these battles with the British Crown, Georg translated his book into German, resulting in his recognition, in Germany, as a genius endowed with the highest qualities of humanity.

Georg Forster

First Attempts to Reach the Pole

The *Resolution* sailed from Plymouth, England toward the coast of Spain, on July 13, 1772, crossing the Equator on September 9, thus beginning a journey that would last three years and sixteen days, in the course of which the equivalent distance of three times the circumference of the globe would be travelled. Four approaches toward the South Pole would be made during the summer months of the Southern Hemisphere.

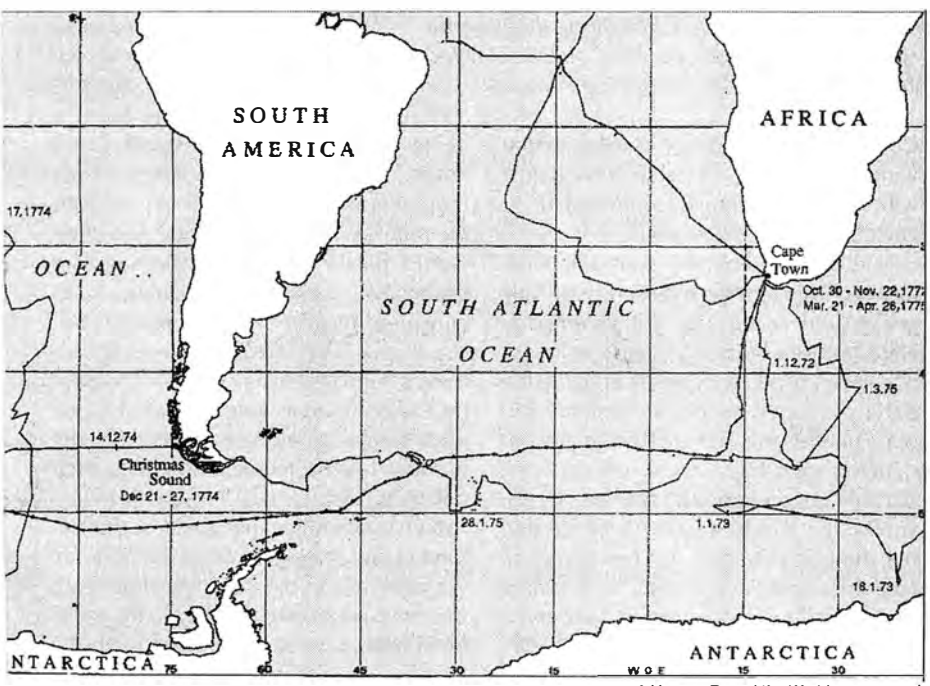
On December 9, with the temperature at about freezing, being at 49° 45′ south latitude, they see large ice floats, one being 2,000 feet long, 400 feet broad, and 200 feet high. On the 10th, Forster writes: "The ice likewise served to shew us the great difference between the temperature of the northern and southern hemisphere. We were now in the midst of December, which answers to our June, and the latitude observed at noon gave only 51 degrees 5 minutes south, notwithstanding which we had already passed several pieces of ice, and the thermometer stood at 36 degrees. The want of land in the southern hemisphere seems to account for this circumstance, since the sea, as a transparent fluid, absorbs the beams of the sun, instead of reflecting them" (p. 65).

They crossed the Antarctic Circle on January 17, 1773, seeing more than 30 large islands of ice and a glaring white reflection from the sky over the horizon. Persevering, they passed through a vast quantity of broken and spongy brown ice which thickened around them. Reaching 67° 15′ south latitude on the 18th, with an immense field of ice extended southward, Cook, seeing that it was impossible to advance any farther, ordered the ship to head northeast. By January 31, having gone northeast up to a latitude of 50° south, a new southeastern approach was made.

On February 24, at about 6° south, they were once again stopped by a field of solid ice. The obstacle, however, this time pleased nearly everyone on board, having been so long at sea, more than three months without fresh nourishment, and with the weather auguring a fierce winter in these seas, the nights now lengthened, making navigation more dangerous.

"It was therefore very natural," says Forster, "that our people, exhausted by fatigues and the want of wholesome food, should wish for a place of refreshment, and rejoice to leave a part of the world, where they could not expect to meet with it" (p. 76).

Several people now had advanced signs of scurvy. The violent climate had also affected the livestock, which had been taken on board and were intended as gifts for the natives of the South Sea islands. Goats and sows either miscarried, or their offspring were killed by the cold; it would take nearly another four weeks, much of which was spent in icy waters, before touching land at Dusky



A Voyage Round the World, pp. xxx-xxxi

Bay, New Zealand.

R & R in the South Seas

The ship's R & R was not exactly what Hollywood has popularized about the South Seas. For those of you who might have been overdosed with a romanticist notion of beautiful, half-clad maidens, innocently and freely generous with their "favors"—think again! Here is Forster's description of these lovely creatures:

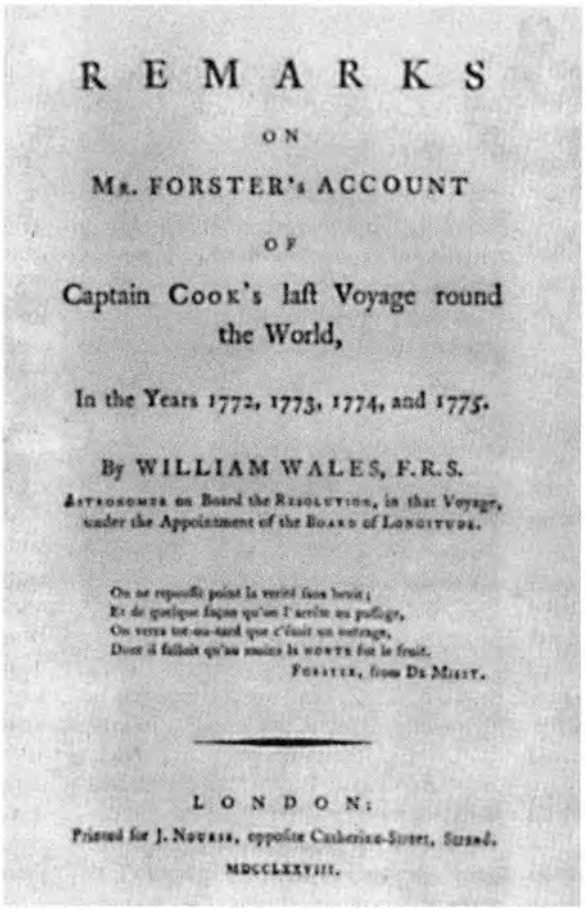
"In the afternoon, many of our sailors were allowed to go on shore, among the natives, where they traded for curiosities, and purchased the embraces of the ladies, notwithstanding the disgust which their uncleanliness inspired. Their custom of painting their cheeks with ochre and oil, was alone sufficient to deter the more sensible from such intimate connections with them; and if we add to this a certain stench which announced them even at a distance, and the abundance of vermin which not only infested their hair, but also crawled on their clothes, and which they occasionally cracked between their teeth, it is astonishing that persons should be found, who could gratify an animal appetite with such loathsome objects. . ." (p. 123).

Second Attempts to Reach Pole

They had spent the winter travelling from Dusky Bay, to Queen Charlotte's Sound, New Zealand, to the Society Islands (Tahiti, Hauhine, and Raiatea), to the Tongan archipelago and back to New Zealand, improving their diet, brewing anti-scorbutic tea, mapping, and exploring. When summer came, everyone dreaded the new attempts that would be made to find the southern continent; they had not fully regained their health from the previous summer, they now knew the hardships to be expected, and they no longer believed that they would find land.

By December 15, 1773 surrounded by a thick fog and amid great numbers of floating rocks of ice, their situation was extremely dangerous. About one o'clock in the afternoon, there was the sudden appearance of a large island of ice just ahead. Keeping as near to the wind as possible, the ship passed just within her own length windward of it. Forster writes of this event:

"Notwithstanding the constant perils to which our course exposed us in this unexplored ocean, our ship's company were far from being so uneasy as might have been expected; and, as in battle the sight of death becomes familiar and often unaffecting, so here, by daily experiencing such hair-breadth escapes, we passed unconcernedly on, as if the waves, the winds, and rocks of ice had not the power to hurt us. The pieces of ice had a variety of shapes, in the same manner as those which we had observed to the southward of the Indian Ocean; and many pyramids, obelisks, and church-spires appeared from time to time. Their height was not much inferior to that which we had observed among the first islands of ice in 1772; and many likewise resembled them in being of a great extent and perfectly level at top. . ." (p. 288).



REMARKS

ON

MR. FORSTER'S ACCOUNT

OF

Captain Cook's laſt Voyage round the World,

In the Years 1772, 1773, 1774, and 1775.

By WILLIAM WALES, F.R.S.

ASTRONOMER on Board the RESOLUTION, in that Voyage, under the Appointment of the BOARD of LONGITUDE.

On ne repouſſe point la vérité ſans horreur;
Et de quelque façon qu'on l'arrête au paſſage,
On verra toujours que c'eſt un outrage,
Dont il faudra qu'on rougiſſe le MOINS fort le fruit.
FORSTER, from DE MISSY.

LONDON:

Printed for J. NOURSE, oppoſite Catherine-Street, Strand.

MDCCLXXVIII.

A Voyage Round the World, p. 698

Title page of William Wales's pamphlet attacking the 1777 English edition of Forster's book. The quotation in French, which Wales attributes to "Forster, from De Missy," reads: "The truth cannot in silence be dismissed; and however it be halted along the way, this will be seen as an outrage one day, whose fatal fruit was shame at least."

Is This British Culture or Hell?

Two days before Christmas, surrounded by islands of ice, many on board are painfully ill including Johann Reinhold Forster, who is bedridden with crippling rheumatic pains and fever. The wretched conditions in his cabin render it rotting with mold, and only two and one half degrees warmer than upon the open deck.

Ninety large ice islands were in sight on Christmas day. "This being Christmas-day, the captain according to custom, invited the officers and mates to dinner, and one of the lieutenant's entertained the petty-officers. The sailors feasted on a double portion of pudding, regaling themselves with the brandy of their allowance, which they had saved for this occasion some months before-hand, being sollicitous to get very drunk, though they are commonly sollicitous about nothing else. The sight of an immense number of icy masses, amongst which we drifted at the mercy of the current, every moment in danger of being dashed to pieces against them, could not deter the sailors from indulging in their favourite amusement. As long as they had brandy left, they would persist to keep Christmas 'like Christians,' though the elements had conspired together for their destruction. . . . Though they are members of a civilized society, they may in some measure be looked upon as a body of uncivilized men, rough, passionate, revengeful, but likewise brave, sincere, and true to each other" (p. 290).

Georg describes the scene of the following day: "Towards noon the next day we were still in the same situation, with a very drunken crew, and from the masthead observed one hundred and sixty ice islands, some of which were half a mile

long, and none less than the hull of the ship. The whole scene looked like the wrecks of a shattered world, or as the poets describe some regions of hell; an idea which stuck us the more forcibly, as execrations, oaths, and curses re-echoed about us on all sides" (p. 291).

And here is how the Crown treated its guest scientists:

"In order to fit the ship for sea she was cut down at Sheerness, and the round-house, formerly intended for the Captain's reception, was thrown off. This so much lessened the room in the ship, that we, as the last comers, found only two small cabins, one on each side, nearly abreast of the main mast, and unconnected with any other cabins. They had been patched up in a hurry, and standing where the ship supports the greatest strain, were open to the winds and waves, which forced into them through every cranny.

"The Captain was so sensible of their uncomfortable condition, that he offered of his own accord to enlarge my father's cabin and make it contiguous to that of the master. The Captain, first Lieutenant, Astronomer, and Master had excellent roomy cabins on the same deck, supported by each other, and not torn to pieces by a continual strain. They had large scuttles, which admitted sufficient light, whilst we could scarcely see a glimmering through a small hole overshaded by the chain plates. Morning and evening every day, on washing the decks, our cabins were filled with water over the ancles, and by this means, or when it rained, or as often as a wave struck over the ship, our beds were thoroughly drenched; and this hardship was wholly confined to ourselves, all the other cabins being watertight and warm. By living in these wretched hovels, my father was tortured with rheumatic pains, which frequently confined him to his cold damp bed, and once laid him up during two whole months, whilst we cruised to the Southward among the ice in December, 1773, and January, 1774. I was likewise plagued with frequent illness and scorbutic complaints" (p. 790).

The *Resolution* advanced northward as much as the winds would permit, and lost sight of the ice on January 1, 1774, at 5° 7′ S. latitude. Forster reports: "On the 4th, the wind blowing from the westward was very boisterous, and obliged us to keep all our sails double-reefed; the sea ran high, and the ship worked very heavily, rolling violently from side to side."

But they have achieved something: "[I]t is sufficient for us, to have proved that no large land or continent exists in the South Sea within the temperate zone, and that if it exists at all, we have at least confined it within the antarctic circle" (p. 292).

On January 11, the *Resolution* changed course, and was now running southeast again, when on the 15th the wind increased greatly into a tempestuous gale. Forster recalls:

"At nine o'clock a huge mountainous wave struck the ship in the beam, and filled the decks with a deluge of water. It poured through the sky-light over our heads, and extinguished the candle, leaving us for a moment in doubt, whether we were not entirely overwhelmed and sinking into the abyss. Every thing was afloat in my father's cabin, and his bed was thoroughly soaked. His rheumatism, which had now afflicted him above a fortnight, was still so violent as to have almost deprived him of the use of his legs, and his pains redoubled in the morning. Our situation at present was indeed very dismal, even to those who preserved the blessing of health; to the sick, whose crippled limbs were tortured with excessive pain, it was insupportable" (pp. 292-293).

The distress of the crew was exacerbated by the condition of their rations. Their biscuits, brought on board at New Zealand, were now largely decayed, and for economy sake they received only two thirds of their usual allowance, one half of which was rotten. The first ice islands met with on this run were at 62° 30′ south, on January 20. Proceeding southward, they crossed the Antarctic Circle again on the 26th. On that day an illusion of land appeared, which after a few hours vanished in the clouds. On the 27th, they reach 67° 52′ south, farther south than any of the former attempts, and met no ice to stop them.

They were now once more in the regions of perpetual day, and had sunshine at the hour of midnight. Able to pass through a large bed of broken ice, the hope was held of penetrating to the south as far as other navigators had gone towards the North Pole.

But on January 30, at about seven o'clock in the morning, a solid ice-field of immense proportion was before the ship as far as the eye could see. They had reached a latitude of 71° 10′ south, that is 18° 50′ north of the South Pole, "but as it was impossible to proceed farther, we put the ship about, well satisfied with our perilous expedition, and almost persuaded that no navigator will care to come after, and much less attempt to pass beyond us. From these circumstances my father has been led to suppose, that all the south pole, to the distance of 20 degrees, more or less, is covered with solid ice, of which only the extremities are annually broken by storms, consumed by the action of the sun, and regenerated in winter" (p. 295).

They began to run north. "[A] great number of our people were however afflicted with very severe rheumatic pains, which deprived them of the use of their limbs; but their spirits were so low, that they had no fever . . . and my father, who had been in exquisite torments during the greatest part of our southern cruize, was afflicted with tooth-aches, swelled cheeks, sore-throat, and universal pain till the middle of February, when he ventured on deck perfectly emaciated" (p. 295).

The Main Purpose Accomplished

"The principal view of our expedition, the search after a southern continent within the bounds of the temperate zone, was fulfilled; we had even searched the frozen seas of the opposite hemisphere, within the antarctic circle, without meeting with that vast tract of land which had formerly been supposed to exist. At the same time, we had made another discovery important to science, that nature forms great masses of ice in the midst of the wide ocean, which are destitute of any saline particles, but have all the useful and salubrious qualities of the pure element. At other seasons we explored the Pacific Ocean between the tropics, and in the temperate zone; and there furnished geographers with new islands, naturalists with new plants and birds, and, above all, the friends of mankind with various modifications of human nature. In one extreme we saw, and not without compassion, the dull,

hungry, deformed savages of Tierra del Fuego, incapable of guarding against the severities of their wretched climate, and having their mental faculties reduced to that miserable situation which places them next to brutes. In the other, the happier tribes of the Society Islands, beautifully formed, placed in a delightful climate, which supplies all their wants; sensible of the advantages of a well-ordered society, affectionate towards each other, and accustomed to gratify their senses, even till they lead to excesses. From the contemplation of these different characters, the advantages, the blessings which civilization and revealed religion have diffused over our part of the globe, will become more and more obvious to the impartial enquirer. . ." (p. 684).

The Return

It would take the *Resolution* nearly another year and a half on the return voyage before they would once again set foot in England.

During this phase of the journey, the *Resolution* would make stays at Easter Island, the Marquesas Islands, the Society Islands (for the second time), Niue, Tonga, Namoka, the New Hebrides, New Caledonia, Norfolk Island, Queen Charlotte's Sound (for the third time), Tierra del Fuego, New Year's Islands, Patagonia, Possession Bay, the Cape of Good Hope, St. Helena, Ascension Island, and the Azores, before anchoring at Spithead, England on July 30, 1775.

Between the time of the *Resolution's* return to England, and the completion of Forster's book, the world would become forever changed by the signing of the American Declaration of Independence, and it is clear that the mind of Georg Forster, as reflected philosophically throughout this book, is implicitly that of an "American." Georg would later become a mentor to the young Alexander von Humboldt, with whom he journeyed, in the spring of 1790, from Mainz through northwest Germany, the Netherlands, and France, to England and back. The account of that journey (*Views of the Lower Rhine*) was written in 1792 by Forster himself, and Alexander von Humboldt pays homage to Forster in his *Cosmos*.

Forster would also come to know Benjamin Franklin. When describing a water spout seen off the coast of New Zealand, Forster says, "all our observations only tend to confirm the facts already noticed by others, and which are so largely commented upon by the learned Dr. Benjamin Franklin, F.R.S. His ingenious hypothesis, that whirlwinds and water-spouts have a common origin, has not been invalidated by our observations. . ." Forster then refers his "philosophical readers" to Franklin's philosophical papers, as "containing the most complete and satisfactory account of water-spouts" (p. 113).

The Tories' Revenge

The vengeance with which William Wales, the voyage astronomer (by appointment of the Board of Longitude), sought to silence Georg Forster and his father, presumably with the blessings of the Earl of Sandwich and the British Crown, was massive. Wales issued a lengthy and boring pamphlet, which used the art of outright lies, quibbles, character assassination, and fallacy of composition. Wales attacked everything including Forster's waterspout observations, naturally, without mentioning Benjamin Franklin. Wales reveals himself a Tory lickspittle when, in his attack on Johann Reinhold Forster for attempting to change his miserable living conditions on board, Wales cannot write "king," but must bow down before the monarch, by writing it "k-g," as if the king were God!

"We had scarce got out to sea, before he quarrelled with Mr. Gilbert, the master, and treated him in a very ungenteel manner, because he did not chuse to give up part of the space which had been assigned by the Commissioners of the navy for his cabbin, that the Doctor might enlarge his own with it; and, what was yet more extraordinary, when he found he could not obtain it, was even guilty of so much folly as to threaten him with complaining to the k-g at his return. . . ."

Perhaps K-g G-e the T-d should have done some soul-searching regarding the following scene, described by Forster:

"Mr. Pickersgill proposed to purchase the head [of a youth killed in battle], in order to preserve it till his return to England, where it might serve as a memorial of this voyage. . . . We were all occupied in examining it, when some New Zeelanders came on board from the watering-place. At sight of the head they expressed an ardent desire of possessing it, signifying by the most intelligible gestures that it was delicious to the taste. Mr. Pickersgill refused to part with it, but agreed to cut off a small piece from the cheek, with which they seemed to be well satisfied. He cut off the part he had promised, and offered it to them, but they would not eat it raw, and made signs to have it dressed. Therefore, in the presence of all the ship's company, it was broiled over the first; after which they devoured it before our eyes with the greatest avidity. The captain arriving the moment after with his company, the New Zeelanders repeated the experiment once more in his presence. It operated very strangely and differently on the beholders. Some there were who, in spite of the abhorrence with which our education inspires against the eating of human flesh, did not seem greatly disinclined to feast with them, and valued themselves on the brilliancy of their wit, while they compared their battle to a hunting-match. On the contrary, others were so unreasonably incensed against the perpetrators of this action, that they declared they could be well pleased to shoot them all. . . .

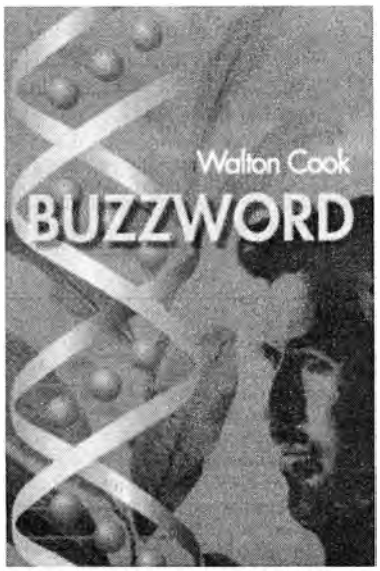
"But the sensibility of Mahine, the young native of the Society Islands shone out with superior lustre among us. Born and bred in a country where the inhabitants have already emerged from the darkness of barbarism, and are united by the bonds of society, this scene filled his mind with horror. He turned his eyes from the unnatural object, and retired into the cabin, to give vent to the emotions of his heart. There we found him bathed in tears; his looks were a mixture of compassion and grief, and as soon as he saw us, he expressed his concern for the unhappy parents of the victim" (pp. 278-279).

Georg Forster died in poverty in Paris at the age of 40. But he had left his imprint on one of the great friends of America, Alexander von Humboldt, and his passing was mourned by one of the giants of the 19th Century, Heinrich Heine. His contributions now come back to life in this wonderful book, which was withheld from the English-language reader for the last 224 years.

Biotechnology Can Dry Up Terrorist Financing

by Valerie Rush

Buzzword
Walton Cook
Ashland, Ohio: Public Policy Press, 2001
Paperback, 380 pp., $15.95



Buzzword, by Walton Cook, suggests a new approach to the war on narco-terrorism. Cook argues—in fictional form—for the mass deployment of bio-engineered, host-specific plant pathogens against the world's coca and poppy crops, the source of cocaine, opium, and heroin narcotics. Cook's scientifically detailed solution, if effectively deployed by governments, not only would wipe out a significant portion of the illegal drug trade, but, by doing so, *would* also help to dry up an important source of financing for terrorist operations around the world.

The exciting potential raised by Cook's novel, which is based on the real-life research of real-life scientists, makes *Buzzword* a must read: not only for the political, military, and intelligence communities directly responsible for battling narco-terrorism, but for the average citizen who has for too long been battered by media lies, which insist the war on drugs can never be won, and that "legalization" is the only solution.

Buzzword tells the story of plant pathologist Dr. Alex Wyckham, whose quiet life in the South American Andes, dedicated to building a better potato, is shattered when his beloved wife is murdered by a drug-lord after she accidentally stumbles upon his guerrilla-protected trafficking operation in the jungles of Peru. Backed by a couple of good guys inside the U.S. diplomatic and intelligence community, Dr. Wyckham embarks on the ultimate revenge—genetically engineering a pathogen capable of wiping out the region's coca plants. But when he tries to get U.S. government backing to deploy his "bioweapon" against the drug trade, he is stymied.

To this reviewer's mind, here is where the novel gets especially interesting. The arguments Dr. Wyckham encounters from the Pentagon, the State Department, the Drug Enforcement Administration, the White House, and so forth, are in many ways identical to arguments employed today by drug legalization advocates, in all their guises.

For example, the "environmentalist" insists, won't the anti-drug pathogen mutate and wipe out our food supply, or worse? And what if coca proves to be medically viable? The "human rights" lobby protests: doesn't this violate the rights of the coca-farmers, who rely on these drug crops for a living? The free-marketeer demands: What right do we have to deprive an individual, or a nation, of their income? And if we do, how do we contain the hordes who will want to descend on the United States?

And then there are the other arguments, which insist that Wyckham's solution would constitute a "violation of national sovereignty," "an act of biological warfare," an "assault on private property," and so on.

Dr. Wyckham, *Buzzword*'s hero, refutes these arguments, one by one, by taking the higher standpoint that political expediency must always yield to moral and ethical truth, otherwise known as natural law.

Wyckham is ultimately denied official U.S. government authorization for his scheme, forcing him to turn elsewhere for backing. And when he becomes a target for assassination by the combined forces of drug lords and mafia dons—and by a U.S. government-sanctioned hit-squad!—Wyckham is forced to go underground while readying his biowarfare scenario for deployment.

A Question of Political Will

With all the exciting potential Cook's *Buzzword* proposal offers, Wyckham's is, unfortunately, not the "final solution" for the drug trade plaguing our planet, much less an answer to the criminal empires whose money supply he wants to cut off. Nonetheless, drying up the cocaine and heroin trade, and the vast hot money flows it engenders, is clearly both necessary and doable, as *Buzzword* so eloquently demonstrates. All that is required is the political will.

Valerie Rush is a journalist with Executive Intelligence Review, who has written extensively on the Andean drug trade.

Adult Stem Cells

Continued from page 53

pelvis using local anesthesia. The stem cells in the marrow were concentrated outside of the body and implanted in the infarct area the next day with a special technique via a coronary artery. However, the doctors could not yet take cardiac tissue to prove definitively that the implanted blood stem cells had converted to heart muscle cells. But, according to Strauer, there is no other way to explain the marked improvement in the patient's condition. After this first successful operation, six more patients have already been treated with their own stem cells, with similarly positive results.

There are also reports of successful treatments with adult stem cells in cases of Crohn's disease (a chronic infection of the gut), thalassemia (a blood disease), and a rare skin disease. And—despite the fact that basic research with adult stem cells is in its earliest beginnings and is in no way being promoted with urgency—there have been a growing number of reports lately of experiments with animals, from which it emerges that adult stem cells can successfully transform themselves into differentiated cells of organs of many kinds.

In contrast, reports of successful conversions of embryonic stem cells are very infrequent and cautious. Thus, we find in *Science* of Dec. 1, 2000 (Vol. 290, pp. 1672-1674): "In contrast, the human embryonic stem cells and fetal germ cells that made headlines in November 1998 because they can, in theory, develop into any cell type have so far produced relatively modest results. Only a few papers and meeting reports have emerged from the handful of labs that work with human pluripotent cells. . . . The work suggests that it will not be simple to produce the pure populations of certain cell types that would be required for safe and reliable cell therapies. . . ."

This is the restrained language used by established science to describe a truly disastrous set of results.

There are, of course, still substantial problems to be overcome, even with adult stem cells: They are relatively rare, and are hard to find with the techniques used so far. They are also not very easy to culture outside of the body. It was therefore an important advance that Australian researchers of the Walter and Eliza Hall Institute of Medical Research have now found a way to isolate nerve stem cells with "extreme purity" from the brains of mice. In *Nature* of August 16, 2001 (Vol. 412, pp. 736-739), they reported obtaining a culture of 80 percent purity, compared to a previous rate of 5 percent at best.

It is now urgently necessary to tackle the research in precisely this direction, in order to find out the exact conditions under which the differentiation of stem cells comes about and how, in detail, it proceeds. Only by this morally unassailable route will it be possible to develop new therapies for serious, heretofore incurable diseases, and beyond that, to improve our understanding of the development of life itself.

Wolfgang Lillge is the Editor-in-Chief of the German-language Fusion *magazine. His article appeared in the Sept.-October 2001 issue of* Fusion, *and was translated into English by David Cherry.*

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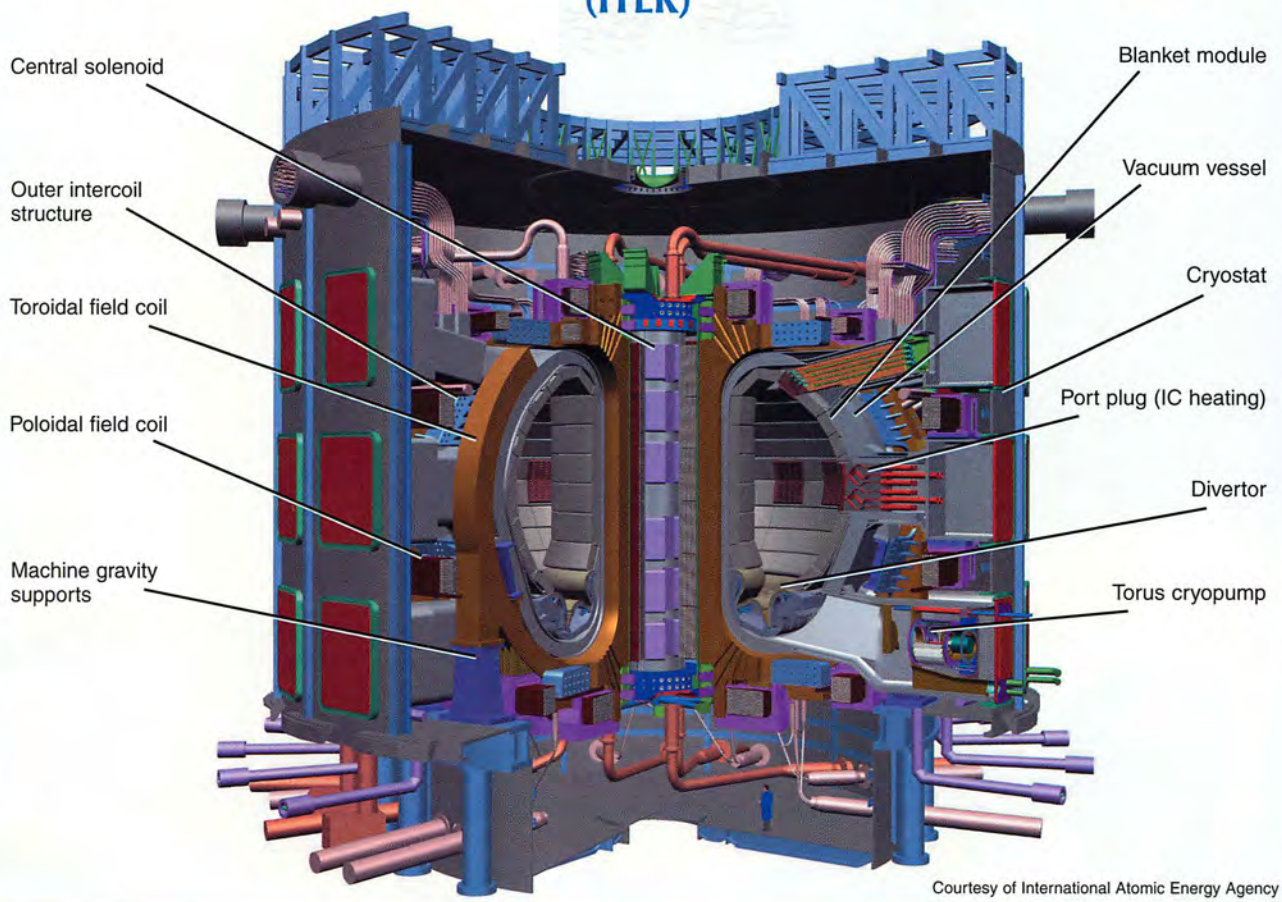
THE INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR (ITER)



Courtesy of International Atomic Energy Agency

The international effort to construct the world's first continuous-burn fusion reactor is moving ahead. The European Union, Russia, Japan, and Canada have decided to begin construction of the new machine in 2003, at a site to be chosen soon. The ITER device will be capable of generating 500 megawatts of fusion power for hundreds of seconds, and is intended as a step toward the development of a demonstration fusion power plant that could generate large amounts of electricity continuously (see Fusion Report).

Fusion is the energy process that powers the Sun. The nuclei of light elements, such as hydrogen are fused, or joined together, under conditions of very high temperature and pressure, producing a new element, and in the process releasing more energy than was required to cause the fusion. The problem of harnessing fusion power is how to contain the super-hot gas of hydrogen isotopes, known as a plasma, which contains the nuclei that must be fused. The plasma is so hot that it would melt a crucible made of any known material, so some other means must be found to contain it. The two principal methods of plasma containment are known as magnetic confinement (sometimes called a "magnetic bottle") and inertial confinement (which includes laser fusion).

ITER is a magnetic confinement device. The key to magnetic confinement is that the plasma is an ionized gas, meaning that it consists of positively charged electrical particles. Charged particles can be controlled by the fields of powerful magnets, just as the electrons in a television picture tube are guided by magnetic coils surrounding the tube. Much of the research in fusion power has been devoted to finding the best ways to configure the magnets so as to best contain the plasma and cause fusion to occur.

The ITER is the type of magnetic confinement design known as a tokamak. It is a toroidal (donut) shape, as can be seen here in the cross section, with a major radius of 6 meters (about 19 feet). Two sets of wire coils (field coils) carry high-energy electric currents which produce the magnetic fields that contain the plasma. These are the **toroidal field coils** which curl around the small radius of the torus, and the **poloidal field coils,** which go the long way around the torus. The field coils are superconducting and must be kept at very low temperature within a **vacuum vessel** by the **cryostat** and **torus cryopump.** The **central solenoid** induces a current within the plasma particles.

The fusion fuel, a mixture of the hydrogen isotopes deuterium and tritium, is heated to millions of degrees celsius, while the magnetic fields trap the resulting plasma, causing repeated collisions, and producing more energy than that consumed by operating the reactor. The heat produced by the reaction can be absorbed by the **blanket module.** A **divertor** skims impurities from the plasma. In an actual commercial reactor, the heat from the fusion process would be used to produce steam to drive electrical generators, or power industrial processes.

In This Issue:

William Hodges, "*H.M.S. Resolution* off Cape Stephens with Waterspout," National Maritime Museum, London (reproduced from the cover of *A Voyage Round the World*, University of Hawai'i Press, 1999.

THE SUPPRESSED STORY OF CAPTAIN COOK'S SECOND VOYAGE

George (Georg) Forster's first-hand account of Captain Cook's 1772-1775 voyage to the South Seas, including his dramatic attempt to establish the existence of the Antarctic continent, has been suppressed in English for more than 200 years. Georg was the son of Johann Reinhold Forster, the ship's naturalist, and his 1777 English-language book fell victim to a campaign of slander and vilification. He then translated his book into German, resulting in his recognition in Germany as a genius and humanitarian. In 1999, the University of Hawai'i Press brought out this magnificent two-volume book in English. It is reviewed in the Books section by Rick and Lenore Sanders.

Photos by Sara Madueño

Bust of Pedro Paulet and a model of Paulet's Torpedo Plane, both in the Pedro Paulet room of the Aeronautical Museum of the Peruvian Air Force in Lima.

PERUVIAN WAS FIRST ROCKET SCIENTIST

Pedro Paulet (1874-1945) was a pioneer of space aviation, who invented a liquid fuel motor in 1895 and the first modern rocket propulsion system in 1900. A Peruvian statesman and educator, Paulet devoted his life to promoting a universal scientific and classical education as the basis for progress throughout the world. His great niece Sara Madueño tells the story of Paulet, who was born into a poor mestizo family in a Peruvian village and had, from early childhood, a passion for reaching the stars in a "flying machine."