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21st CENTURY SCIENCE & TECHNOLOGY

Vol. 15, No. 1 Spring 2002

Features

The increasing prominence of skeptical environmentalist Bjorn Lomborg was too much for Scientific American, *which devoted 11 pages in its January 2002 issue to a hit-and-run attack on Lomborg, written by leading Malthusian scientists. The Special Report by Ralf Schauerhammer, "Why There Really Are No Limits to Growth," examines the faulty premises of both the Malthusians and Lomborg and his free market supporters.*

On the cover: Top left, Peruvian-born astronaut Carlos Noriega on a space walk (courtesy of NASA); lower left, artist's conception of the Argentine satellite SAC-C, fully deployed in orbit (courtesy of CONAE); lower right, Brazil's VLS rocket (courtesy of Space Agency of Brazil). Cover design by Alan Yue.

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21st Century Science & Technology (ISSN 0895-6820) is published 4 times a year in 2000, every third month, by 21st Century Science Associates, 60 Sycolin Road, Suite 203, Leesburg, Va. 20175. Tel. (703) 777-7473.

Address all correspondence to **21st Century**, P.O. Box 16285, Washington, D.C. 20041.

Second-class postage is paid at Leesburg, Va. and additional mailing offices.

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POSTMASTER: Send address changes to 21st Century, P.O. Box 16285, Washington, D.C. 20041-0285.
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Printed in the USA ISSN 0895-682
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Teach Gauss's 1799 Proof Of the Fundamental Theorem of Algebra

We have all heard the frequent laments among our co-thinkers and professional colleagues at the sadly reduced state of science and mathematics education in our nation. As in all such matters, after the righteous indignation and hand-wringing, is over, one must ask oneself the realistic question: Are you part of the problem, or part of the solution?

If you are not sure, we have a proposal for you. To introduce it, I ask you to perform the following experiment.

STEP 1: As a suitable subject, locate any person who has attended high school within the last 50 or so years. You may include yourself. Now, politely ask that person, if he or she would please construct for you a square root.

"What do you mean construct a square root? I know what a square root is, but what do you mean 'construct' it?" is a typical answer from one sort of person.

"I was never good at math. I'm not a math person," is the usual form of the other type response. Curiously, I have found that it is from this category of respondents that the correct solution is more likely to appear rapidly. In either case, some degree of resistance, tempered by a natural curiosity, is most often encountered at this point.

STEP 2: Remain calm, but resolute. Draw a square on a piece of paper, and ask the question again. "Here is a square, please show me the square root."

Among the technically educated, it is very common, next, to see the diagonal of the square appear, often with the label $\sqrt{2}$ attached. As this has nothing whatsoever to do with the solution, I have found it most effective to point out in such cases, that the problem is really much simpler than that. No knowledge of the Pythagorean Theorem, nor any higher mathematics, is required.

A discussion of what is meant by a square root may now prove useful. I mean a very simple discussion. At this point, from among that second category of subjects, I have seen the light bulb go on rather quickly in a few cases. From the technically educated category, I have most often encountered a furious spurt of calculating and sketching, to no good end, sometimes followed by resignation. But, with persistence, these too will solve it. The exercise of constructing the square and rectangular numbers, as Theaetetus describes it in Plato's dialogue of that name, can serve as a useful flank on the mental block encountered.

An Induced Mental Block

What is the problem? No student of the classical method of education, which has been around for at least the past 2,500 years, could ever have any problem with this simple exercise. The mental block which arises here is the perfectly lawful result of the absurd and prevalent modern-day teaching that number can exist independent of any physically determining principle. This is the ivory-tower view of mathematics, which holds sway from grade school to university, and reaches up like a hand from the grave, even into the peer review process governing what can be reported as the results of experimental physics.

This was the view that the young Carl Friedrich Gauss so devastatingly attacked in his 1799 "Proof of the Fundamental Theorem of Algebra,"[1] submitted as his doctoral thesis to the University of Helmstedt. That every algebraic equation of degree m, where m is a positive integer, will have m roots, was a matter usually learned as a truism in any high school-level advanced algebra course, at least until the recent bad times. The proof of the assertion was not a matter one usually addressed. However, one has to take the student no further than the simple illustrative case $x^2 + 1 = 0$ to cause a recognition of the essential paradox involved.

In the usual training, one is taught to

write $\pm\sqrt{-1}$ as the two solutions.

"What is the square root of minus 1?"

"Ahem, that's complicated; we may address that later."

Mathematicians have known of this problem since at least 1545. In that year, Girolamo Cardano published a delightful account in Chapter XI of his *Ars Magna.* Here Cardan solves the problem "find two numbers whose sum is 10 and whose product is 40." After showing us that the solutions must make use of the square roots of −15, Cardan examines what such a thing might be. Ask yourself: If a square root is the length of a side of a certain square number, what is the area of the square, the length of whose sides are negative? Finally, the Bolognese mathematician concludes his discussion of the paradoxical solution he has found (not without a bit of tongue in cheek, we presume): "This subtilty results from arithmetic of which this final point is, as I have said, as subtile as it is useless."[2]

So the matter remained for two-and-a-half centuries. Despite the technically elegant proofs of the Fundamental Theorem of Algebra, provided successively by d'Alembert, Euler, and Lagrange, no resolution of the fundamental paradox of the existence of the 'imaginary' number had been made. As Bruce Director explains in the Pedagogy section of this issue (p. 66), Gauss's new proof of the fundamental theorem, written at the age of 21, was an explicit and polemical attack on the shallow misconceptions of his celebrated predecessors. Gauss's solution, which subsumes his creation of the complex domain, establishes the so-called imaginary numbers as perfectly lawful entities, with no handwaving required.

From that point onward, the sorts of sophistry, which still persist in the teaching and practice of this subject matter, were no longer necessary. The ivory tower practice of mathematics was no longer necessary, nor desirable. In its place must be the insistence which had always governed mathematics from the time of the Greeks, that nothing be accepted as true for which we could not provide a constructible representation.

This does not mean a crass empiricism. As Gauss showed for the case of the solution of algebraic functions, and as was already recognized in the writings of Plato, a higher concept of magnitude requires an act of the mind. That granted, nothing is to be accepted as true in mathematics, which does not correspond to a principle of physical action. "It works," or "it is consistent with our defined set of allowable operations and procedures," is, therefore, not acceptable. By accepting such shortcuts, first truth is destroyed, then science, then economies and whole nations.

A New Curriculum

Our proposal, suggested by Scientific Advisory Board member Lyndon H. LaRouche, Jr., is this. Let the mastery of Gauss's fundamental theorem as developed in his revolutionary 1799 proof, serve as a cornerstone of a new curriculum for secondary and university undergraduate students. As LaRouche argued in motivating this proposal:

"Gauss's devastating refutation of Euler's and Lagrange's misconception of 'imaginary numbers,' and the introduction of the notion of the physical efficiency of the geometry of the complex domain, is the foundation of all defensible conceptions in modern mathematical physics.... It also provides a standard of reference for the use of the term "truth," as distinct from mere opinion, within mathematics and physical science, and also within the domain of social relations. Those goals are achieved only on the condition that the student works through Gauss's own cognitive experience, both in making the discovery and in refuting reductionism generically. It is the inner, cognitive sense of 'I know,' rather than 'I have been taught to believe,' which must become the clearly understood principle of a revived policy of a universalized Classical humanist education.

"Once a dedicated student achieves the inner cognitive sense of 'I know this,' he, or she has gained a benchmark against which to measure many other things."

We heartily concur, and urge our readers to join us in taking up the pedagogical challenge implied. Let the inspired item in our Pedagogy section serve as introduction. —*Laurence Hecht*

Notes

1. Carl Friedrich Gauss, "New Proof of the Theorem That Every Algebraic Rational Integral Function in One Variable Can be Resolved into Real Factors of the First or the Second Degree" (Helmstedt: Fleckeisen's, 1799). English translation by Ernest Fandreyer, Prof. of Mathematics, Fitchburg State College available at: http://libraserv1.fsc.edu/proof/gauss.htm
2. Hieronimus Cardanus, *Ars Magna* (1545) ff. 65v. and 66r. transl. by Prof. Vera Sanford in D.E. Smith, *A Source Book in Mathematics,* (New York: Dover, 1959) pp. 201-202.

Letters

Fermat's Principle

To the Editor:

I read with interest your editorial on Fermat's principle ["Why You Don't Believe in Fermat's Principle," Fall 2001, p. 2]. I have not seen your viewpoint expressed elsewhere. I think there is little doubt that Fermat's principle, and the principle of least action to which it led, are hiding quantum aspects of nature of which the originators of those principles were entirely unaware. The really radical thing about quantum theory is not the "quantization" aspect but the nonlocal-action aspect. That is what gets swept under the rug, but always keeps peeping out under misleading and confusing guises such as "EPR" [the Einstein-Podolsky-Rosen paradox].

In a sense, the photon has to know where it is going before it can go . . . and that is precisely the nonlocal aspect of the situation. Unlike a bird or a photon, we cannot ourselves be in two places at once, hence the sweeping under the rug. And of course, nothing is helped by Einstein's "insight" concerning the "relativity of simultaneity." The accompanying conviction that distant simultaneity is "meaningless," together with slavish adherence to Einstein's belief that all distant action is causally retarded, guarantees enduring confusion among physicists about the basic structure of the world.

Thomas E. Phipps, Jr.
Urbana, Ill.

Radiation and Cancer

To the Editor:

As a physician specializing in the treatment of cancer patients using radiation, I read with great interest Jerry Cuttler's article "The Significant Health Benefits of Nuclear Radiation" in the Fall issue [p. 48].

In clinical external beam radiotherapy we typically use large doses of carefully directed ionizing radiation to eradicate tumors while sparing normal tissues. In order to achieve this goal we exploit physics to accurately target the tumors (through the use of modern techniques such as 3-Dimensional Conformal Radiotherapy and Intensity-Modulated Radiation Therapy), and radiobiology to minimize the deleterious effect on the normal tissue that is inevitably exposed.

A large enough acute dose of radiation will destroy practically any human tumor, but will also destroy any adjacent normal tissue. By fractionating the large dose into smaller, daily doses, normal tissues can be largely spared while the tumor is still eliminated. Thus, although we are dealing with daily doses that are still quite large (on the order of 2 gray per day), normal tissues are still able to repair themselves with surprising efficiency in most cases.

As Cuttler points out, the public and scientific community are well aware of the deleterious effects of large acute doses of radiation but the biological effects of low doses and dose-rates are far more obscure. While the LNT [Linear No-Threshold] hypothesis is attractive for its simplicity, there are little human data at low exposures. As the article mentions, there are numerous epidemiological studies that refute the LNT hypothesis, and some which actually support the opposite view; namely, radiation hormesis, the concept that small doses of radiation are actually beneficial. While the cohort studies cited in the article are intriguing, hard-core skeptics will remain unconvinced by any observational study and may remain unconvinced by any data short of a prospective randomized trial, which will never happen.

Part of the skepticism may stem from the question of why there would be no negative effect (or perhaps a positive effect) at low doses, when it clear that large doses are so harmful. As Cuttler mentions, cells respond to radiation by increasing their levels of protective enzymes such as superoxide dismutase (SOD) and DNA repair mechanisms. (In fact, we occasionally exploit a similar phenomenon by administering pharmacological doses of synthetic radioprotectants such as amifostine, a thiol-containing free radical scavenger, to further protect normal tissues during radiotherapy).

Perhaps a better understanding of why such natural protective mechanisms are in place in all living organisms can come from evolutionary biology and the geological sciences. The Earth was formed roughly 4.6 billion years ago, and the first direct evidence of life appears around 3.6 billion years ago in the form of stromatolites, mats laid down by cyanobacteria. (Indirect evidence of life can be found can be found even earlier in ratios of carbon-12 to carbon-13 in rocks, suggestive of photosynthesis.)

At the time that life was evolving on this planet, ambient background radiation levels were much higher than they are today, because of the greater abundance of naturally occurring radioisotopes. Potassium-40, the greatest source of internal radiation dose (0.2 mGy/yr on average now), contributed estimated doses of 1.6 mGy/yr early in Earth's history. External exposure from radioactive elements in the uranium and thorium series has declined over the eons as well. The net result is much less radiation exposure today from natural background sources compared to the time when life first evolved (over five-fold on average).

The highly efficient DNA repair mechanisms now in place in all organisms evolved in the distant past when radiation levels were much higher than at present. Accordingly, they are perhaps equipped to handle radiation levels much higher than currently exist. In light of these considerations, the concept of low doses of radiation not being of great harm seems far more plausible. In fact, in this light, the admittedly highly controversial concept of some human maladies being due to a "radiation-deficiency syndrome" may not be as far-fetched after all.

James Welsh, M.S., M.D.
University of Wisconsin-Madison
Medical School,
Madison, Wisc.

Evolution and Mind

To the Editor:

An argument you make in your reply to a letter from Rhodes W. Fairbridge in the Winter 2001-2002 edition ["An Earth Scientist Appreciates Vernadsky," p. 4] is rather puzzling to me.

Even if "Cognition and the higher processes of life, are merely more such accidents" there is no reason, in my thinking that "there is no reason to construct any such thing called science."

Simple logic dictates that because the first may be true, the second certainly does not have to be, and the fact that science does exist certainly isn't any proof that "cognition and the higher processes of life" are not just accidents.

Given that the higher processes were just an accident, it would be truly amazing! But, as good scientists, this possibility can not yet be ruled out.

Mike Bluett
Vancouver, B.C., Canada

The Editor Replies

The passage to which you are referring reads:

"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 point you may be missing, is that accident, by its nature, cannot be a lawful cause. Perhaps the widespread prevalence of statistical "explanations" in what passes for modern science contributes to your confusion.

We do not accept the premise that everything passing under the name "science" in modern university departments is such. Increasingly it is not. Science is dying, and almost dead. When it comes to fundamental theoretical work, we have a preponderance of textbook-educated parrots, who have no clear idea where the ideas they are repeating come from. Otherwise, we have many talented experimenters, who are held back by their sloppy mastery of basics, and their refusal to challenge the prevailing doctrines of classroom mathematics.

Our problem, the mission of our magazine, is to re-create a modern science capable of carrying on this noble tradition, which was already in its death throes by the onset of World War I. This requires an assault, above all, on the doctrines of accepted classroom mathematics. The standard of proof in the physical sciences, as by algebraic equivalence or statistical mechanisms, must go. Scientific progress has been stifled for most of the past century under a tyranny of pseudo-mathematical drivel, introduced through such channels as Bertrand Russell's Unification of the Sciences project.

The best remedy for the individual seeking truth is to throw away the textbooks and most of the gobbledygook of modern "scientific" commentary. Go back to the original, fundamental discoveries and relive them in your own mind and workshop. A return to such classical principles, as the standard of educational practice is necessary if science is to survive.

On the Origin of Life

To the Editor:

In biology lessons, we were taught that the first living thing is a primitive one-celled organism. However, there are still a few points that confuse me. It would be very much appreciated if you would answer the questions I pose below:

(1) How did the first living thing come into existence by itself? In the past, if one cell came into existence by itself in the primitive conditions, then why can't anyone bring one cell into existence under the high-tech laboratory conditions? Even one of the organelles located inside a cell such as mitochondria, golgi apparatus, endoplasmic reticulum cannot be brought into existence.

(2) It is realized, by looking at their fossils, that some living beings have not been changed over millions of years. For instance, fish fossils of 400 million years before the present, dragonfly fossils of 140 million years, ammonite fossils of 350 million years, scorpion fossils of 320 million years. How could the above-mentioned living beings manage to reach the present time without undergoing any evolutionary process?

(3) Let us put plenty of materials present in the composition of living beings such as phosphorus, nitrogen, carbon, oxygen, iron, and magnesium generously in plenty of big barrels. Moreover, we can add into these barrels any material that does not exist under normal conditions, but you consider as necessary. Let's add as much amino acids and proteins as we like to the mixture, and expose these mixtures to as much heat and moisture as they like. Let's call the world's best-known scientist beside the barrel. Let these experts wait by the barrels from father to son, from generation to generation for billions or even trillions of years. Let them be free to form every condition they think would be necessary for the existence of a living thing.

After all these means, do you think actors like Clark Gable, Humphrey Bogart, or scientists like Einstein would come to existence out of these barrels? I mean, can a human that has the ability to think, talk, feel, innovate, and observe his own cells under an electron microscope come into existence out of them? Or, can giraffes, lions, bees, canaries, parrots, horses, dolphins, rose, orchids, cloves, bananas, oranges, apples, figs, olives, grapes, peafowls, pheasants, butterflies or millions of other species be brought into existence?

(4) The ability to see the world very sharply is a matter that I take into consideration occasionally. I examined the highest quality television systems, and realized that they cannot provide an image as sharp as a human eye can. There are television producing companies, such as Sony, Philips, with plenty of scientists and engineers working in them. Although they have all the technology and many years of experience, they cannot attain the vision quality of a single human eye. Then, would it be reasonable to consider this incredible vision system formed as a result of blind coincidences?

(5) I considered the same situation for sound. The hearing system of a human is surprisingly qualified. Despite the existence of hundreds of thousands of engineers working in well-known companies, such as Pioneer, Kenwood, Hitachi, they cannot obtain a clear sound without any static as in a human ear. How can an ear that is made up of flesh and bone develop such a perfect sound system? If we accept them to be the result of blind coincidences, then wouldn't it require that we put forth that the engineers and the technicians are not as smart as these coincidences?

(6) As I have learned from the books I have read so far, there is no transitional form indicating that a living thing turned into another by evolutionary means. Is it correct?

Baran Uygar
baranuygar@hotmail.com

The Editor Replies

You raise some interesting questions. The implied critique of the theory of chance evolution, I agree with. How can chance be a scientific explanation of anything? However, if your alternative is the theory known as Creationism, I disagree.

We have the geological evidence of an apparent evolution in time of increasingly complex life forms. We also have the present-day evidence of a vast array of now-living forms, which, when arrayed hierarchically, suggest a progressive development from simple to complex, as if by plan. Even if the progressive development were not over time, one would still have to account for it.

It is useful in matters such as these, to distinguish between explanation by *efficient cause* and by *final cause,* as Gottfried Leibniz pointed out. Science must always seek to explain phenomena by reference to efficient cause, that is, by analogy to some mechanism or other form of intelligible representation, and not rely on invoking miracle or divine intervention, whenever a difficulty arises. On the other hand, that there is a final cause in every thing, which is the expression of the end or perfection toward which all things in the universe are striving, is also the foundation of science. For, if there is not a principle of ordering to be discovered in the universe, there is no point to rational science.

The interesting paradox arises when we examine the means by which we discover a valid universal physical principle. Science begins with the recognition that the evidence of the senses is invalid: the real physical world is not a projection of self-evident objects onto our sensory apparatus, as if on a movie screen.

Objects, in fact, do not exist. What exists, as we discover by valid attempts to scientifically study the false appearances presented to us by our sensory apparatus, is a process of continuous change.

To examine this, begin from the observation that we know three interrelated yet distinctly different types of processes in the world around us, which we can describe as abiotic, living, and cognitive. Life, as you note, cannot be explained as a spontaneous outgrowth of the abiotic. Thus, even though all living things are analyzable into the 92 elements, an assemblage of the precise chemical and structural composition corresponding to a living thing does not produce life. What is the distinction between the same assemblage of matter a moment before, and one moment after death?

Similarly, for the distinction between an Idea (in Plato's sense of the term, which would subsume a valid scientific hypothesis), and a living being. Although uniquely associated with the human cognitive faculty, that is, to a particular type of living being, a valid hypothesis is absolutely distinct from the living matter with which it is associated; indeed, it can live on for thousands of years after the biological death of its innovator.

Let us view this paradox as it arises in physics, for example, which examines the lowest of the three levels of phenomena. In the development of any fundamentally new physical principle, we start from the identification of something paradoxical, anomalous experimental phenomena which do not fit our existing hypothesis of the ordering of nature. Notice, that already we are discussing, at once, all three of the identified types of processes which are the subject of science, that is, the relationship of abiotic phenomena to the mind of the living process.

Now, by a step in the process which is not subject to formal representation, a new idea arises in the mind of the investigator. To test that idea, an experimental apparatus and design is conceived. The purpose of the experiment is to determine the relationship of the idea in the mind (level 3) to the abiotic processes (level 1) as mediated by the sensory apparatus (level 2). Foolish empiricists, who are not the people who conceive valid new universal physical hypotheses, suppose that the subject of the experiment is the relationship among the presumed, self-evident elementarities of level 1.

Ask now, by what means can the distinctly different phenomena of these three levels of processes communicate with each other? How does mind act upon living body and living body upon abiotic processes, and how the reverse? Only by such considerations, may we proceed to a clearer understanding of a concept of evolution that goes beyond either the triviality of randomness or the formal sterility of a fundamentalist's creation.

There is more to be considered. For a fuller discussion, we refer you to the book by Lyndon H. LaRouche, Jr., *Economics of the Noösphere,* available from www.larouchepub.com

Modern Interferometers And Dayton C. Miller

To the Editor:

I was reading recently about NASA's plans to build and place an interferometer in orbit around the Sun. This brought to mind the cover story in the Spring 1998 issue of *21st Century Science & Technology* on the work of Dayton C. Miller ["The Experiments of Dayton C. Miller (1925-1926) and the Theory of Relativity," by Maurice Allais and "Optical Theory in the 19th Century, and the Truth about Michelson-Morley-Miller," by Laurence Hecht].

If Miller did indeed detect an ether drift, I wondered, would this new space-based interferometer also detect it?

I looked up the space-based interferometer on the Internet. I found that NASA are already building a ground based interferometer at Mount Palomar. Called the "Palomar Testbed Interferometer," this is a prelude to another interferometer to be built at the Keck Observatory on Mauna Kea, Hawaii, called the Keck Interferometer. The Keck Interferometer will eventually have a maximum light path of 140 m. The light path to Miller's interferometer was 32 m.

I wondered if the Keck Interferometer would detect an ether drift, but I could immediately see two problems with this idea:

(1) The Keck light path will pass through an underground tunnel. Miller, when commenting on other ether drift experiments, criticized them for "massive and opaque shielding" which would cancel out the effects of an entrained ether.

(2) The sophisticated systems used to calibrate the instrument may cancel out an ether drift without it ever being detected. For example, regarding a test of the interferometer the web site stated: "In addition, the optical system in the tunnel adjusted the light path to within a millionth of an inch." If an optical system is used to adjust the light path, and if this adjustment is automatically done each time as observation is made, then any ether drift may be cancelled out. The only way to see if this is happening would be to analyze the adjustments of the light path done each time.

The space-based interferometer, I hope, would not suffer from point (1). Spacecraft have to be as light as possible, and I could not imagine the usefulness of any excessive and heavy shielding over the light path, in the vacuum of space. It may suffer from point (2), but this should be possible to turn off, or to study the calibrations made by the computer systems for a discernible pattern that would indicate an ether drift.

The space-based interferometer, called the "Space Interferometry Mission" or SIM, is scheduled for launch in 2009. Would it, in your opinion, be possible to study the results of the SIM to prove or disprove the ether drift theory?

Stuart Twyford
Melbourne, Australia
stuart@wizard.teksupport.net.au

The Editor Replies

I share your enthusiasm that modern instruments might contribute to our understanding of the unanswered problems in the theory of light. I do not have the specialized knowledge to answer your specific questions regarding the named instruments, but invite comments from informed readers.

You ask whether results from the space-based interferometer could finally prove or disprove the ether-drift theory. I think not. Since the Michelson-Morley, and subsequent Miller experiments did not produce a null result, the widely accepted view that the speed of light is indifferent to both the direction of propagation and velocity of the source is not well-founded. But neither do experimental results substantiate a simple interpretation of ether drift. The true answer would seem to lie in "none of the above."

The Moon and Longitude

To the Editor:

Thank you for thought-provoking articles on the ancients' abilities to measure longitude ["Ancient Navigators Could Have Measured Longitude!" by Rick Sanders and "Building and Using Maui's *Tanawa*" by Bertram Cooper, Fall 2001, p. 58]. . . .

Question for my understanding: Considering the variability of the Moon's orbit compared to that of the stars, why did Mr. Sanders choose the Moon's orbit as the celestial body of choice in establishing longitude. . . .

It is my opinion that the single most important factor in determining longitude would be the tables of celestial positions at the reference meridian, and the hour angle, H, measured by the *torquetum* at the new location. This is because, for the same instant of time, the ecliptic coordinates remain fixed, but the equatorial coordinate, hour angle H, changes by one degree for each one degree of longitude change.

Therefore, if the mariner has kept track of the time lapse since departure, and can find the table readings for the current day, the difference in the hour angle as read vs. the table, would indicate the longitude difference from the reference meridian.

My understanding is that lack of closely reproducible cycles makes the Moon a not-so-reliable reference for this. (The alignment of the sidereal month, perigee of orbit, and line of Nodes occurs approximately every 1,656 years. Thus the lunar cycles would vary with each monthly cycle, whereas the stellar cycles would be fairly constant—subject to the Equation of Time, Nutation, Precession, and so on.)

I thoroughly enjoyed your magazine and all of the articles, especially these two.

John D. Shotzbarger,
BSEEE
Minneapolis, Minn.

Rick Sanders Replies

First, let us use a non-astronomical example to demonstrate a similar principle, where our sense certainty presents us with a paradox. You see someone chopping wood, or firing a rifle, 300 yards away. First you see the blow, or see the smoke from the muzzle, then some time later, you hear the sound. At first you are astonished, because, like an animal, or an empiricist, you are so used to linking the eye with the ear for that same event. But now, there seem to be two events! This simple paradox helps us calculate the speed of sound through the air.

Lunar distance works for a similar reason. But I did not choose the Moon—the Moon chose me! There is no other way. The problem in finding longitude is that all the "motions" of the stars, as everyone knows, but everyone forgets, are not real, but caused by the turning of the Earth. The Moon's east to west "motion" has the same cause. However, the Moon has a real motion independent of our rotation, in the opposite direction, as you know, from west to east.

The trick is in your comment: "If the mariner has kept track of the time lapse since departure." Aye, there's the rub. Before chronometers, the only available "time-piece" that was sufficiently accurate, was the Moon: Change in lunar distance (which you cannot see with the naked eye, but you can *measure* with a naked eye instrument, such as a torquetum), will tell you how many hours have elapsed relative to that place on Earth for which the Almanac you are carrying with you, was compiled. That will help you calculate your longitude.

Even after the chronometer was invented, lunar distance was always used as a check, by navigators using a special sextant with telescopic sights, well into the 20th Century! On a similar principle, you can also use the satellites of Jupiter as a clock, provided you have a small telescope.

On your remarks of the complexity of the Moon's motion, I stay away from that, because the details—which are in any case irrelevant to the navigation we are talking about—can obscure the principle involved. For example, the Polynesian navigators used a multitude of physical evidence to show them that they were approaching land (the mountainous ones obviously being the easiest), but the presence and flight direction of certain birds, would give a radius of about 20 miles of the "target" island. Thus, for all the Moon's idiosyncrasies, the approximate longitude given by the torquetum would seem to be quite adequate for Pacific island hopping.

Eradicating Drug Growing

To the Editor:

Of course I was delighted by the overwhelmingly positive review of my book, *Buzzword,* written by Valerie Rush in your Winter 2001-2002 edition ["Biotechnology Can Dry Up Terrorist Financing," p. 71]. I'd like to make one point of clarification, however, regarding the fictional versus the real-life deployments of biocontrols to narcotics producing plants, which the book indirectly proposes.

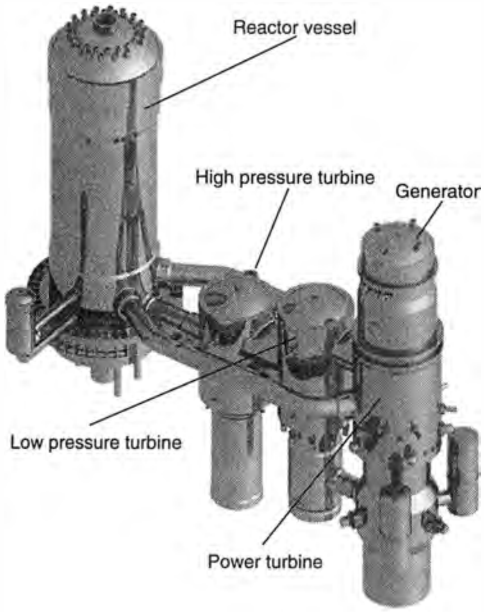
The statement, "Wyckham is forced to go underground while readying his 'biowarfare' scenario for deployment," can easily cause non-fictional misunderstandings. "Biowarfare" is a misleading and damaging definition to apply to the real-life "peaceful" use clauses for bioherbicides under the various current "biowarfare" conventions.

In the real world, one must realize that agricultural biocontrol is a mature and well respected scientific discipline, having begun in the United States in 1884, and its use having contributing to many success stories. Without the ability for nations to use biocontrols, either chemical or natural, control of many of the weed, insect and other plant pests would not be possible.

In the current debate over using "narcotics biocontrols" or mycoherbicides to restrict the growth of narcotics producing plants, one must realize that many nations consider such plants illegal for cultivation, and others have most recently shown willingness to use biocontrols against them within their own borders, a designated peaceful use.

Therefore, use is not "warfare" unless undertaken against the will of a grower nation, not however, with its consent! That gives nations that recognize the connections between narcotics growth and trafficking and terrorism a chance to sever that ugly connection. It's an important semantic distinction.

Walton Cook
Author of *Buzzword*



The steel pressure vessel of this 110-MW PBMR reactor design is 6 meters in diameter and about 20 meters high, inside a building that is 21 meters below ground. Its 310,000 fuel balls ("pebbles") are each the size of a tennis ball.

EXELON WITHDRAWS FROM SUPPLIER END OF PEBBLE BED REACTOR

Exelon Generation, which has been a partner in the development of South Africa's Pebble Bed Modular Reactor project, announced April 16 that it "will not be proceeding with the project beyond the completion of the current feasibility study phase." The U.S.-based company said that it wants to focus on electricity generation, power marketing, and distribution, and not become a reactor supplier. In an announcement of its withdrawal, Exelon stressed that it believes that the PBMR technology has the "potential to be viable and successful," and that "the project is now positioned for other companies with the appropriate expertise and core business experience to deliver the PBMR plants to power generators such as Exelon Generation." Exelon had a 12.5 percent stake in the project.

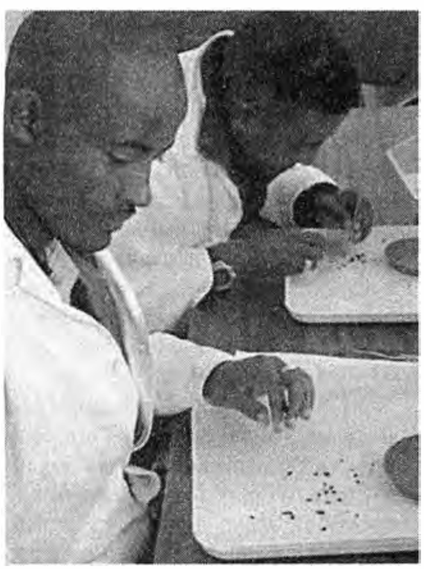
PBMR head Dave Nicolls praised Exelon's involvement in the project over the last two years, and said that its departure "will not materially affect the long-term viability of the PBMR technology in the world market."

See p. 74 for an update on the PBMR.

CHINESE LAUNCH THIRD SHENZHOU TEST SPACECRAFT FOR MANNED FLIGHT

At 10:15 PM local time, on March 25, China launched the third unmanned version of the spacecraft it will use to take the first Chinese astronauts to space. *People's Daily* reported that the return module is "expected to return in a few days," but the orbital module may be in space much longer. Shenzhou II stayed aloft for nine months.

People's Daily also reported that Shenzhou III has an "additional module." According to space analyst Charles Vick, this new feature appears to be a platform that may be attached to the front of the vehicle. Vick told *space.com:* "In general, we should not underestimate the Chinese and their capabilities, especially since they are building a second launch site that's almost complete." Having two launch pads would allow China to launch Shenzhou vehicles in quick succession, which could dock in orbit, and form a space station complex. Chinese space officials stated that if all the unmanned Shenzhou tests are successful, a manned mission could take place next year. After the Soviet Union (1961) and the U.S. (1962), China would become the third nation to launch its own astronauts.



IAEA

Technicians in Ethiopia's tsetse fly breeding center separate larvae before they hatch.

OAU LAUNCHES NEW CAMPAIGN TO ERADICATE THE TSETSE FLY

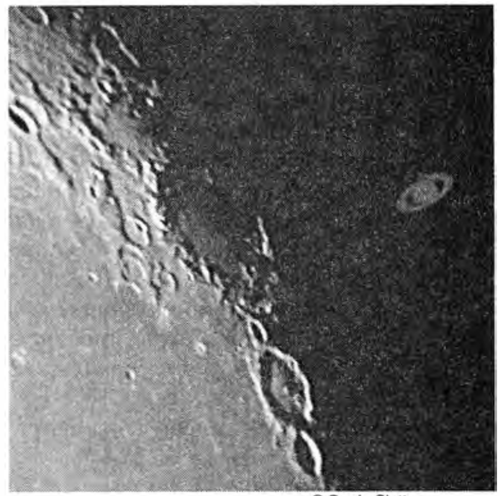
The Organization of African Unity launched a new campaign to eliminate the African tsetse fly, a parasitic carrier of sleeping sickness. The fly now infests 37 sub-Saharan African nations, and as many as 500,000 people have sleeping sickness, which kills 80 percent of those infected. In some regions, sleeping sickness kills more people than any other disease, including AIDS. The disease also kills an estimated 3 million livestock animals per year, and prevents some of Africa's best land from being cultivated.

As described in a Feb. 19 press release of the International Atomic Energy Agency, the campaign will introduce hundreds of thousands of sterile male flies into the breeding population of target regions. The flies are laboratory-bred, and made sterile by gamma irradiation, which impedes the fertility of the sperm but not their functioning. The sterile males mate, but the eggs produced in the female do not develop. The sterile insect technique, combined with the use of insecticide, was used successfully to clear the island of Zanzibar of tsetse in 1997.

The current sleeping sickness epidemic began in the mid-1970s, according to the World Health Organization, after systematic screening and treatment from 1940 to 1960 had almost eliminated the disease. The international reports do not mention either the conditionalities of the International Monetary Fund and other world agencies that forced budget cuts for health and development services, or the policy changes that stopped the use of DDT and other pesticides.

SATURN LUNAR OCCULTATIONS PROVIDE SPECTACULAR IMAGES

For the past few months, Saturn has been in the position in the sky where it is periodically blocked from Earth view by the Moon. This photograph, taken by Dennis Slattery in California on Dec. 28, 2001, captures the two bodies before the Moon glides in front of the ringed planet. It takes 2 minutes for the Moon's limb to cover Saturn's rings, during which times astronomers try to see if they can discern any new detail in the rings, as the Moon covers the light from the planet itself. For more views of the occultation, see http://www.spaceweather.com



© Denis Slattery

The Moon and Saturn, taken through an 8-inch Schmidt-Cassegrain telescope.

DANISH GOVERNMENT CANCELS WIND FARMS AS TOO COSTLY

The Danish government decided Jan. 24 to drop plans for installing three offshore wind power farms by 2008, which were to have a generating capacity of 450 megawatts, one fifth of Denmark's wind generating capacity. Industry and Economics Minister Bendt Bendtsen justified his decision by stating "We are very concerned about the costs for society and for Denmark's competitiveness if we continue to expand the use of green energy." Bendtsen told the Danish economic daily, *Borsen,* that Denmark has already exceeded its political target of 20 percent of renewables in the energy supply by 2003. "Our figures show that we are now at 27 percent," he said. The last study of the European Commission on the subject was less optimistic, calculating 7.8 percent for that figure. Bendtsen said that the cancellation of the three wind power farms will save $ 21.3 million for consumers, who are now obliged to buy the renewable electricity at a high price. In a ministerial order issued Dec. 7, 2001, Bendtsen proposed a change in payment for wind energy, dropping payments to owners of wind turbines by almost 30 percent—from 0.60 Danish kroner per kilowatt hour to 0.43/kwh.

KENYAN RESEARCHER SUCCESSFUL WITH NUTRITION TREATMENT FOR AIDS

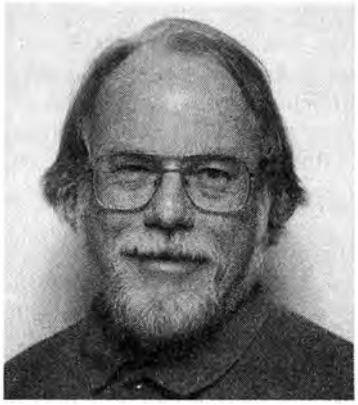
Charles Mbakaya, a senior science researcher at the Kenya Medical Research Institute (Kemri), has successfully treated AIDS patients with a nutritional treatment, reports the *East African Standard.* Mbakaya began his nutritional research after reading a medical article a few years ago that compared the symptoms of AIDS to those of zinc deficiency, and noted the importance of zinc for the immune system. Mbakaya found a commercial dietary supplement high in zinc, and two years ago, assisted by Winfred Kisingu from Kemri and Dr. Patrick Orege from the National Aids Control Council, he began treating 44 people from the Association of People Living with AIDS.

The results after two years show that the supplement, VIUSID, reduced the viral load in HIV positive individuals by more than 50 percent, and, in 19 percent of the patients, it reduced it to undetectable levels. Within three months of using the supplement, 80 per cent of the patients reported that signs and symptoms associated with HIV had resolved, and opportunistic infections had disappeared. Clinically, the VIUSID supplement, which is produced by a Spanish company, has no marked side effects.

COMPLAINT FILED AGAINST PETA WITH INTERNAL REVENUE SERVICE

The Center for the Defense of Free Enterprise has filed a complaint with the Internal Revenue Service against People for the Ethical Treatment of Animals (PETA), asking that PETA's non-profit status be revoked for violations of tax laws and connections to unlawful activity. The 12-page complaint outlines PETA's illegal activities, including its support for the Animal Liberation Front and the North American Earth Liberation Front, both officially recognized as domestic terrorist groups; its advocacy of arson; and its assault on business executives. The Center's executive vice president Ron Arnold commented: "Tax exempt status is for charitable purposes. There's nothing charitable about encouraging arson." For more details, see www.cdfe.org.

Back to the Moon, Then On to Mars!



by Dr. Wendell W. Mendell

If the United States is to colonize space, the case must be made for going back to the Moon, as a precursor for exploration of Mars. In fact, human exploration of the Moon will accelerate the human exploration of Mars. If exploration of Mars is regarded as only one element of exploration of the Solar System, the establishment of a permanent presence on the Moon is not a diversion or an impediment, but rather part of the historical process. It is a necessary step in understanding human capabilities in space.

Here, in brief, is the historical context in which to see the case for the Moon.

After cancellation of the Apollo Program in the Nixon Administration, NASA ceased long-range planning for human exploration of space. During the mission hiatus that followed the Challenger explosion in January 1986, NASA again began examining possible future scenarios for human exploration beyond Earth orbit. The pace of these studies accelerated after the 1989 speech by President Bush, establishing the short-lived Space Exploration Initiative.

On August 7, 1996, a team of NASA scientists announced observations of a meteorite from Mars as indicating a biological origin for several types of features, implying extant or past life on the red planet. NASA leaders became interested in missions to Mars; and the Mars Design Reference Mission, conceived under the Space Exploration Initiative, became the basis for the space agency's thinking about future human missions into the Solar System.

The Mars Design Reference Mission conservatively assumes chemical propulsion only slightly more advanced than the current state of affairs. Hundreds of tons of mass are required to be launched from Earth orbit for each mission. Choosing interplanetary trajectories that require the least energy from propulsion minimizes the mass in low Earth orbit. Minimum energy trajectories are called conjunction-class missions and require specific orbital alignments of the Earth and Mars. Launch opportunities occur only once every 26 months, but the reasonably consistent energy requirements allow design of a single transportation system for all missions.

"Human exploration of the Moon will accelerate the human exploration of Mars."

Unfortunately, arrival at Mars occurs shortly after the optimal alignment for return to Earth, resulting in surface stay times at Mars on the order of 500 days. Combining the transit times between planets of about 8 months, we end up with the "1,000-day" mission. Although many reports and studies have discussed ways to mitigate the effects of long mission durations on the crew, the assumptions of chemical propulsion (that is, current technology) and minimum energy (that is, minimum cost), lead to scenarios whose characteristics raise significant questions about the health and safety of the members of the crew.

Anyone familiar with human spaceflight understands that these Mars missions exceed any other program in terms of mass delivered to orbit, operational complexity, and stress to the crew. These issues are discussed in detail in a paper presented at the International Astronautical Congress in 1991, by this author. Here, I wish to point to some recent work done on issues related to crew health and safety in long-duration missions.

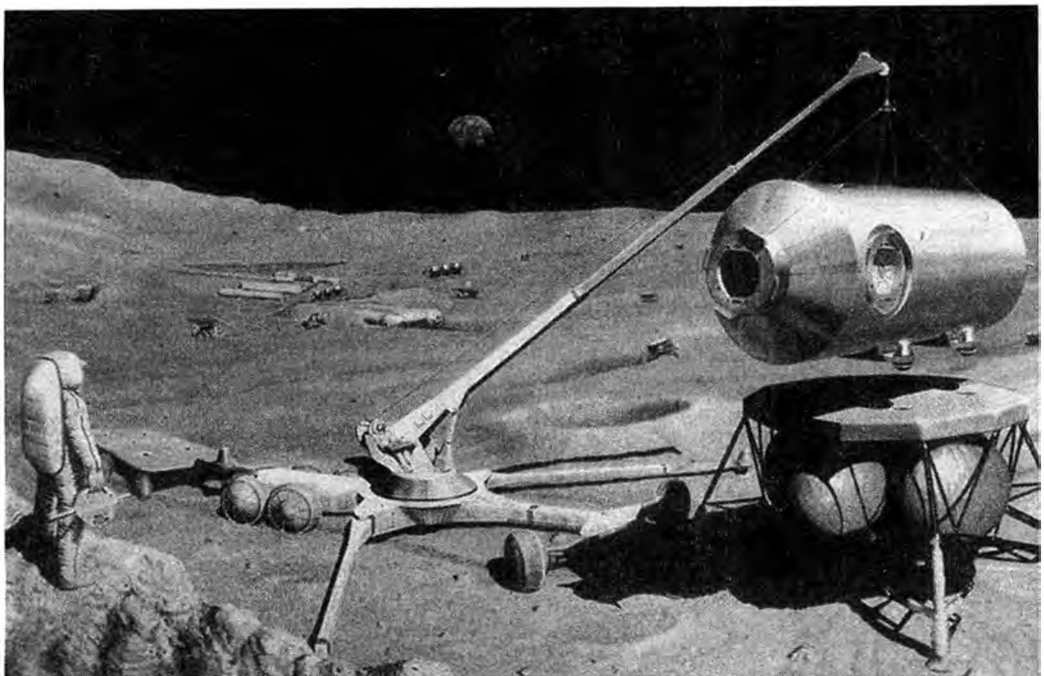
In recent years, the Office of Bioastronautics at the Johnson Space Center has moved to a philosophy of ensuring the safety, health, and performance of the crew during and after spaceflight by identifying, understanding, and managing the risks associated with human presence in space.

To initiate the risk identification process, a team of researchers from NASA and from the National Space Biomedical Research Institute was assembled. The team focussed on what was considered to be the "worst case" scenario—a long-duration, highly autonomous interplanetary mission such as the 1,000-day human expedition to Mars.

Once risks were identified, joint intramural-extramural teams formulated critical questions that must be addressed in order to understand each risk, and eventually mitigate it. Resources available for research are finite, so not every risk can be studied, and not every mitigation strategy can be carried out to the fullest extent. In fact, a total of 55 risks and 341 critical questions about crew health and safety were raised. Therefore, an ongoing process must prioritize risks and evaluate the efficacy of solutions.

The Benefits of Lunar Exploration

The challenges of human exploration of Mars are also elements of human exploration of the Moon. However, we already have mounted brief expeditions to the Moon and understand the operational environment satisfactorily. In fact, lunar exploration provides an ideal context within which to advance our technology to the level required for



NASA

This 1980s artist's rendition of lunar construction on the Moon shows the deployment of a habitat. The painting was presented as a gift to space scientist Krafft Ehricke, who had extensively written on lunar industrialization, at a conference in October 1984, in Washington, D.C., which Dr. Mendell helped organize.

planning Mars exploration.

The Apollo missions demonstrate that no problem exists for adaptation to low gravity for short times. Modern lunar exploration would extend stay time on the lunar surface to months, and would monitor crew performance. Missions that included long duration in weightlessness in Earth orbit combined with lunar surface activity could be used to study the regimes of human performance on a Mars mission.

Cumulative effects of galactic cosmic rays and solar particle events on the crews could be measured. Long-duration lunar surface missions could also contribute to the understanding of psychosocial factors associated with isolation, particularly if the crews lived on the farside of the Moon where the Earth is not visible.

The critical questions can be addressed in a lunar mission context, either as a substitute for an Earth-based research program, or as a supplement to one. Most important, experience gained on the lunar surface raises the readiness to flight-proven status. A lunar program will reassure not only the managers who will be burdened with the decisions, but also the public, which must be comfortable with the risks of Mars expeditions.

'Penny Wise and Pound Foolish'

Cost is a major objection to a lunar program. In my view, this is simply another example of being "penny-wise and pound-foolish." Mars expeditions are several times more expensive and involve serious and unacceptable risks to crew survival. Investment in technology development and research in a lunar program can replace much investment toward a Mars program, if planned wisely.

An objection to going back to the Moon, raised by former NASA Administrator Dan Goldin, is that a lunar program of exploration would preclude exploration of Mars. In this view, vested interests inside NASA and its client aerospace contractors would pursue ever more complex projects related to lunar infrastructure, with no intention to embark on new explorations.

It is true that NASA historically focuses attention on a new major thrust only when the current program is expiring. In other words, future planning is tactical rather than strategic.

But although bureaucratic angst over NASA programmatics is understandable, the idea that humanity will forget about exploration of Mars is patently absurd. That such a concern should exist is evidence that NASA has no intrinsic long-range vision and that the public supporting the space program has not been part of a societal vision for space. Presently, true expectations of future space expeditions reside only in school children.

The objection assumes that exploring the Moon will so exhaust the nation, that no one will have the energy to consider the planets beyond. On the contrary, nowhere in history has opening a frontier induced inertia. Access to a frontier generates creativity and destroys old ways of thinking in the generation that is raised on its threshold.

In sum, a lunar program provides an opportunity to build up space capability in an evolutionary and orderly way, and to broaden the participation of the public in the excitement of space exploration.

Dr. Wendell W. Mendell is a planetary scientist in the Office of Astromaterials Research at the NASA Johnson Space Center in Houston.

Alexander von Humboldt: A Republican Scientist In the Tradition Of Franklin

by Timothy Rush

The most renowned scientist worldwide in the first half of the 19th Century, Humboldt is barely known today in the country of his greatest philosophical affinities, the United States.

Library of Congress

Benjamin Franklin (1706-1790)

The 200th anniversary of the celebrated travels of Alexander von Humboldt in the Americas (1799-1804) is a fitting time to re-examine the work of this titanic figure of 19th Century science. A naturalist, explorer, and philosopher, Humboldt, who lived from 1769 to 1859, was above all a nation-builder, one of a tiny handful of passionate republican intellects who kept the outlook of Benjamin Franklin alive across two generations of oligarchic reaction, to deliver it safely to the age of Lincoln.

A gateway for gaining acquaintance with such a varied life, is Humboldt's own summation of his work. *Cosmos: Sketch of a Physical Description of the World,* was the publishing sensation of mid-19th century Europe. It outsold all books but the Bible in its German editions, and was translated immediately into nine other languages. In *Cosmos,* Humboldt proclaimed the views of science and man which had animated him from his earliest years: in brief, that true wealth is to be found "in Man and the development of his power to discover and create."

Rejecting the racism of the British and other empires, Humboldt boldly proclaimed: "There are no inferior races. All are destined equally to attain freedom."

In his Preface to *Cosmos,* Humboldt says that the "principal impulse" which had "floated before my mind for almost half a century" was "the earnest endeavor to comprehend the phenomena of physical objects in their general connection, and to represent nature as one great whole, moved and animated by internal forces."[1] [See box, page 14.]

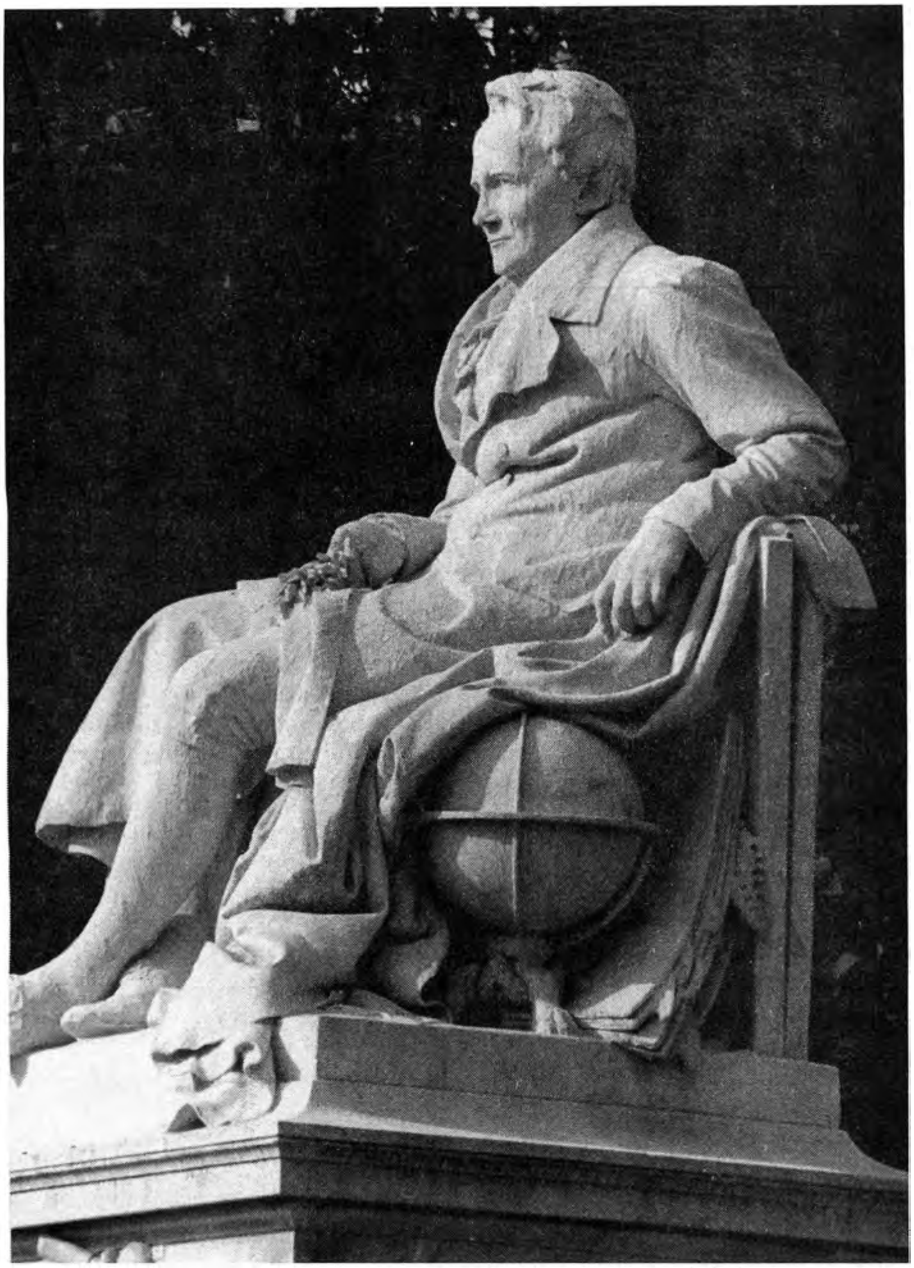
Humboldt's Republicanism

Although born into a family of newly created, minor nobility, and circulating in high social and administrative circles throughout his long life, Humboldt was a thorough republican who revered the principles of the American Revolution. At age 21, he passed through Paris just as the first year anniversary of the beginning of the French Revolution was being celebrated. In this hopeful moment before the Jacobin phase of the Revolution took over, when he thought that the principles of the American Revolution had reached across to Europe, he exclaimed to Georg Forster, his travelling companion,

> The time is already coming, in which people will prize the worth of a man, not because of rank due to birth or accident, nor because of his power or his wealth, but only on account of virtue and wisdom.[2]

Nine years later, while searching for an opportunity to leave the Old World and finding himself stymied by the onrushing Napoleonic Wars, he was no less vehement:

> I am so hampered in all my projects that I daily feel



Statue of Alexander von Humboldt, in front of Humboldt University in Berlin; photo by Chris Lewis/*Fusion*

Alexander Humboldt (1769-1859: "In claiming the unity of the human race, we resist the unsavory assumption of higher and lower races."

inclined to wish I had lived either 40 years earlier or 40 years later. There is only one advantage to be gathered from the present state of things, and that is the extermination of the feudal system and of all the aristocratic privileges which have so long pressed upon the poorer and more intellectual classes of mankind.

These were not idle sentiments for Humboldt. Trained in his early 20s as a mining engineer at the famed Freiburg School of Mining, he was named mining overseer of a large district, and he immediately undertook to improve the conditions of the miners, whose life expectancy was only 30 years. Humboldt set about inventing a series of safety devices and other items of improved equipment, and in testing one of them, almost lost his own life. He recognized that the miners had no understanding of geology or other basics of an education, to more intelligently and safely carry out their work. In a stroke of dissimulative genius, he set up a special school for the miners, which he named the "Royal Free Mining School," even though it had no royal sanction or involvement whatever. Humboldt paid the expenses out of his own pocket. Attendance was voluntary, but the program was a success from the start, and featured aspects of geology and mineralogy, hydrology (the functioning of water tables and the like), local geography, and basic mathematics.

Humboldt wrote at the time:

> If it is a pleasure, to broaden the domain of our knowledge by making new discoveries, then it is by far a greater and more human joy, to discover something which is connected to the preservation of a laboring class of people, with the perfection of any important industry.[3]

One can easily understand Humboldt's excitement at finding an egalitarian commitment to bringing all strata of society forward into productive life, in one experience he records from his travels in New Spain (Mexico) in 1803:

> What a number of beautiful edifices are to be seen in Mexico [City]!. . . Instruction is communicated gratis at the Academy of Fine Arts. Large rooms, well lighted by Argand's lamps, contain some hundreds of young people every evening, of whom some draw from relief or living models. In this assemblage, (and this is very remarkable in the midst of a country where the prejudices of the nobility against the castes are so inveterate) rank, color and race is confounded: we see the Indian and the mestizo sitting beside the white, and the son of a poor artisan in emulation with the children of the great lords of the country. It is a consolation to observe, that under every zone the cultivation of science and art establishes a certain equality among men, and obliterates for a time, at least, all those petty passions of which the effects are so prejudicial to social happiness.

Humboldt, in fact, saw the full participation of *all* the population in upgraded productive activity, not only as desirable, but *necessary* to the successful state:

> Knowledge and inquiry . . . joy and preparation of mankind, these are part of national wealth, often a substitute for those goods which Nature, in all too scanty measure, has apportioned. Those nations, which are inferior in general industrial activity, in the use of mechanics and technical chemistry, in careful selection and transformation of natural resources, [and] in which the attention to such activity does not penetrate all classes, will inevitably see their well-being collapse.

Not surprisingly, Humboldt was a passionate opponent of slavery, and even though his travels in New Spain depended on an extraordinary safe conduct from the court of the Spanish king, his writings on Cuba and Mexico included searing

'Unity and Harmony': Humboldt's V ew of Nature

In his extensive Introduction to *Cosmos,* Humboldt emphasizes that

> Nature considered *rationally,* that is to say, submitted to the process of thought, is a unity in diversity of phenomena; a harmony, blending together all created things, however dissimilar in form and attributes; one great whole animated by the breath of life. The most important result of a rational inquiry into nature is, therefore, to establish the unity and harmony of this stupendous mass of force and matter. . . .[1]

A little phrase in the Summary of Contents which Humboldt himself drafted, is the kernel of his prodigious life labors:

> Necessity for a simultaneous regard for all branches of natural science. Influence of this study on national prosperity and the welfare of nations; its more earnest and characteristic aim is an inner one, *arising from exalted mental activity* [emphasis added].

Later in the text, this notion blossoms into this inspiring passage:

> I take pleasure in persuading myself that scientific subjects may be treated of in language at once dignified, grave, and animated, and that those who are restricted within the circumscribed limits of ordinary life, and have long remained strangers to an intimate communion with nature, may thus have opened to them one of the richest sources of enjoyment, by which the mind is invigorated by the acquisition of new ideas. Communion with nature awakens within us perceptive faculties that had long lain dormant; and *we thus comprehend at a single glance the influence exercised by physical discoveries on the enlargement of the sphere of intellect, and perceive how a judicious application of mechanics, chemistry, and other sciences may be made conducive to national prosperity* [emphasis added].[2]

And a little later, Humboldt writes:

> It is with nations as with nature, which, according to a happy expression of Goethe, "knows no pause in progress and development, and attaches her curse on all inaction." The propagation of an earnest and sound knowledge of science can therefore alone avert the dangers of which I have spoken. Man can not act upon nature, or appropriate her forces to his own use, without comprehending their full extent, and having an intimate acquaintance with the laws of the physical world. . . . The knowledge that results from the free action of thought is at once the delight and the indestructible prerogative of man; and in forming part of the wealth of mankind, it not unfrequently serves as a substitute for the natural riches, which are but sparingly scattered over the Earth.[3]

Note the affinity of this perspective with a crucial quality of conception embedded at the core of American System economics, as expressed by Alexander Hamilton, Lincoln, and LaRouche.[4]

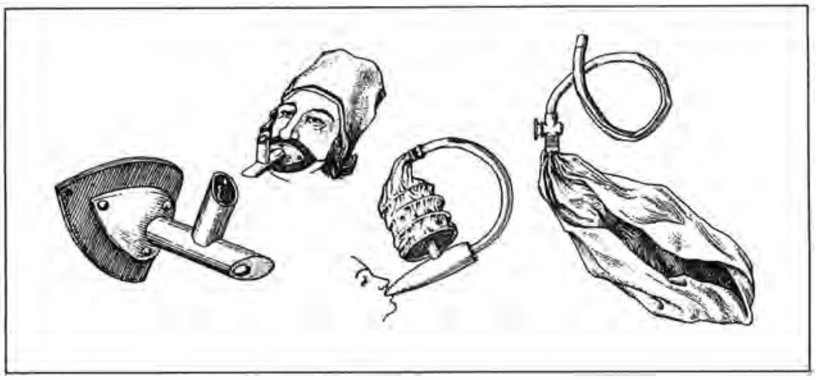
Notes

1. *Cosmos* I, p. 24.
2. *Cosmos* I, p. 52.
3. *Cosmos* I, p. 53.
4. On this requirement of the republican nation state, see Lyndon H. LaRouche, Jr., "The Issue of Mind-Set," *Executive Intelligence Review,* Vol. 27, No. 9 (March 3, 2000), pp. 12-44. LaRouche states (page 33), "For the purpose of the science of physical economy. . . the roles of the two kinds of universal principles are distinguished as follows.

"First, the validation of discoveries of new universal physical principles, leads to the unique experiments needed to prove those discovered principles. By necessity, those experimental designs, if successful, include features which express the distinct principle of the inquiry. Thus, each such application of a new principle, as in different media, and in different combinations of principles, defines what are to be regarded as new *technologies,* technologies expressed in both the design of products, and of productive and related processes. It is by these and related means, that the measurable power of the individual over nature is increased.

"Second, the discovery of such principles and of related technologies, is not sufficient. Although discovery of universal principles occurs, in each instance, within the sovereign powers of cognition of the individual discoverer, the process of transmission of such knowledge, and of its application, *expresses a social process.* Without cooperation among relevant members of society, the propagation and realization of these discoveries and technologies can not occur in such a manner and degree, as to have a notable sort of beneficial effect upon the demographic characteristics of society. Indeed, without such cooperation, such propagation might not occur at all. . . ."

denunciations of slavery, which he never attempted to tone down. In his very last years, he even struck a blow for the establishment of the Republican Party in the 1856 U.S. presidential elections, by writing a condemnation of a bowdlerized edition of his *Political Essay on the Kingdom of New Spain,* which had just appeared in a new U.S. edition (printed in New York), stripped of his denunciations of slavery. An outraged Humboldt wrote that the omitted part had greater importance than all the geography and statistical data put together. He put this condemnation directly in the hands of Gen. John C. Fremont's Republican campaign organization for its use in the campaign. In that same year, Humboldt succeeded in getting a law passed in Prussia that granted freedom to any black slave upon crossing onto Prussian soil. This paralleled his lifelong efforts for full emancipation of Jews in Prussia.



As a young mining official, Humboldt invented this breathing apparatus and other safety devices, out of concern for the terrible conditions under which miners worked.

Humboldt loved to promote far-reaching infrastructure development. Chapter 2 of his *Political Essay on the Kingdom of New Spain,* outlines no less than nine possible sites for an Atlantic-Pacific canal. (One of them became the Panama Canal 100 years later.) Chapter 8 includes a fascinating hydraulic history of Mexico City, with detailed proposals for dealing with the problem of drainage of its site, a valley lacking an outlet. A memorable anecdote from 1844, when Humboldt was a captive of Prussian court politics as King Friedrich Wilhelm IV's chamberlain, recounts Humboldt calling the King's attention to drawings of the then just-completed New York City aqueduct. When the King showed interest, Humboldt reportedly plied him for a week with classic examples of aqueducts throughout history, to stimulate his interest in similar public improvements for Prussia. Throughout the 1840s and 1850s, Humboldt was a patron of great railroad-building projects on both sides of the Atlantic; in fact, he took an interest in all new technological frontiers—from steelmaking to the daguerrotype—all his life.

Transmitting the Legacy of Franklin

The true significance of Humboldt's work can only be seen on a canvas stretching from his formative years in the period of the American and French revolutions, to the Lincoln-era revival of the American System, three quarters of a century later. Humboldt was among the small number of rigorous and courageous intellects who made possible the survival of the American Republic and its mission in the world, over the intervening years of retreat in both Europe and the United States.

In scientific methodology and use of the most advanced measuring instruments of his time, he was a protégé of the circles of both Benjamin Franklin and the Ecole Polytechnique; in broader philosophic matters, his thought was influenced by intense collaboration first with the family and circle of Moses Mendelssohn (see box, page 16), and then with the greatest of the German Classical thinkers, Schiller and Goethe.

Gottlob Christian Kunth, one of the first tutors of Alexander and his older brother, Wilhelm, introduced the Humboldt brothers to the centers of Berlin intellectual life in 1783: the household of Moses Mendelssohn, and the salon run by noted Jewish physician Marcus Herz and his daughter, Henriette. It was in the Herz home, that young Alexander was introduced to the work of Benjamin Franklin, and he replicated several key experiments of Franklin and of Volta. Alexander promptly arranged for a lightning rod to be installed on the Humboldt family home at Tegel, about 10 miles north of Berlin. It was Prussia's second lightning rod, after the one at the University of Göttingen.

Through the Mendelssohn-Herz circle, Humboldt became a defender of Leibniz's scientific and philosophical method (against the "Enlightenment" promotion of the anti-Leibniz Voltaire and Newton), which was the hallmark of the heroic collaboration of Mendelssohn and Lessing in the 1750-1780 period.

During a semester at Göttingen in the spring of 1789, Humboldt studied mathematics with Abraham Kästner, the man who transmitted the Leibnizian outlook to Carl Friedrich Gauss, and who had brought Franklin to Göttingen for a visit during the American Revolution. Humboldt's professor of classical philology and archaeology, Christian Gottlieb Heyne, introduced him to Georg Forster, who 15 years earlier, had travelled the South Seas with Captain James Cook, and was a passionate supporter of the American Revolution. Forster took Humboldt with him as his travelling companion to the Low Countries, England, and France, and sowed the seeds of Humboldt's lifelong passion for exploration.

Humboldt's year of study at the Mining School of Freiberg, and his subsequent employment as mining inspector, brought him into contact with two of the most important pioneers of German industrialization: Abraham Gottlob Werner, head of the school, founder of the study of layering in geology ("geognosy"), and expert in the theory and construction of iron foundries; and Friedrich Wilhelm von Reden, later Minister of Mines in Silesia, who in 1790 had imported Germany's first steam engine from Franklin's circles in England. During three weeks when Humboldt was Reden's houseguest in Breslau, Reden outlined detailed plans to Humboldt, for harnessing the steam engine to ironworks, based on using pitcoal rather than charcoal as the raw material.[4]

A third crucial acquaintance of Humboldt in these circles was Johann Sebastian Claiss, the greatest expert in saltworks of the time. In a letter of early 1792, Humboldt wrote of Claiss:

> He possesses great physical and mathematical knowledge, was seven years in England, worked a great deal with Franklin, was a long time in France. . . and is in charge of all the Bavarian saltworks. I have been asking him questions from morning to night, and I know of no man in whose company I have learned so much. I took many new materials on these matters from Claiss, received also unpublished manuscripts by Franklin on heat contrivances, and completed my map on the relation of all the sources of salt in Germany. The principal idea is . . . that all saltworks in Germany lie in a certain manner, that can be shown through lines on a map, and from which one can find mile after mile of salt sources.

From these kinds of "thinking observations," as Humboldt called them, he was later to develop one of his greatest insights into "unity in diversity": the recognition that similar geological layering characteristics, *wherever in the world they were to be found,* all had to come from a common formative process and share common characteristics. He thus con-

Humboldt and the Mendelssohn Family

All their lives, both Humboldt brothers enjoyed a singular and intense relationship with the family of Moses Mendelssohn (1729-1786) and related Jewish intellectual circles. The importance of Mendelssohn, and his collaboration with Gotthold Ephraim Lessing, has been told in a special issue of *Fidelio* magazine, Summer 1999 (published by the Schiller Institute). Their collaboration was the keystone in igniting the German Classical period, and pivoted on defending and reviving the work of Gottfried Wilhelm Leibniz and Johann Sebastian Bach, against the machinations of Voltaire and other fanatic Newtonians.

The first contact between the Mendelssohns and the Humboldts was in 1783, when Alexander and Wilhelm's mathematics tutor, E.G. Fischer, taught mathematics jointly to the Humboldt brothers and two sons of Moses Mendelssohn. Moses himself, then at the end of his life, became a mentor to Wilhelm. Alexander became close to two of the sons especially, Joseph (1770-1848) and Nathan (1782-1852), and kept them as lifelong friends.

The Mendelssohn family acted as a kind of financial safety net for Alexander throughout his life, as his devotion to his travels and the publications of his works eroded and then used up his own inheritance. For instance, in 1799, when Alexander was in Spain having finally won permission for his trip to South America, his normal bank arrangements broke down. Only a last-minute bank draft from the Mendelssohn family bank enabled his departure. Similarly in 1819, it was the Mendelssohn and Fraenkel bank which stepped in to arrange a credit line in Paris for Alexander to purchase the instruments and books that he needed. At one point after his return to Berlin in 1827, Alexander faced being thrown out of his apartment on the Oranienburger Strasse, when the owner planned to sell the building. The Mendelssohn family secretly bought the building, and made an arrangement for Humboldt to live for the rest of his life in the apartment with no raises in the rent.

But Humboldt found in the Mendelssohn family much more than financial assistance. There was a remarkable ongoing scientific and intellectual collaboration. In 1805, on his first trip back to Berlin since returning from the Americas, he worked with Nathan Mendelssohn on some innovative physical instruments of Nathan's own design. Humboldt demonstrated these intruments at the Berlin Academy of Science.

In 1828, Felix Mendelssohn, grandson of Moses and son of Abraham Mendelssohn, was commissioned to write a special cantata to celebrate the great international scientific conference organized by Humbolt that year. The resultant work, known subsequently as the "Humboldt Cantata," was written for men's voices and an orchestra of basses and cellos, trumpets, horns, and clarinets, to a text by Ludwig Rellstab which celebrated the triumph of the harmony of mind, over the chaos of the elements. One of England's most reknowned "Leibnizians" at the conference, Charles Babbage, wrote that after a walk with Humboldt, "discussing the singularities of several of our learned acquaintances," the two kept their respective engagements, and "met again at the most recherché of all, a concert at Mendelssohn's."

Humboldt's own magnetic researches, reinvigorated by contact with Gauss at the scientific conference, were conducted in special facilities constructed on the property of Abraham Mendelssohn. The following description by Kellner (pp. 119-120) provides a striking portrait of this extraordinary moment:

> . . .a specially-constructed, non-magnetic hut in which all metal parts were made of copper, was set up in the garden of the house of Abraham Mendessohn-Bartholdy... Humboldt's hut was in a corner of the garden, not far from the summer-house where Felix ... and his older sister [Fanny] made music in the evenings and practiced for the great musical event of the spring of 1829, the performance of the newly discovered St. Matthew's Passion [of J.S. Bach], a hundred years after it had first been performed.

In his declining years, after the death of his brother Wilhelm in 1835, the Mendelssohn family—particularly Joseph and his wife—became Alexander's own family, as he spent his birthdays and other special occasions with them.

It is no wonder that Alexander was out of favor in Germany during the Nazi years, accused of "philo-Judaism."

tributed the name and concept of "the Jurassic period" to all subsequent dating schema in geology, after a visit to the Jura mountains. Similarly, during a whirlwind expedition to Siberia in 1829, he made a seemingly preposterous prediction that diamonds would be found in a district on the eastern slope of the Ural mountains—only to have his prediction confirmed even before his return to St. Petersburg five months later.

Science against Empiricism

By 1794, Alexander's older brother, Wilhelm, had taken up residence with his new bride, Caroline von Dacheröden, in Weimar, at the invitation of the "Poet of Freedom," dramatist and historian Friedrich Schiller (1759-1805). It was to be the defining period of Wilhelm's life; the intense collaboration with Schiller and Schiller's circle of friends, bore fruit later in Wilhelm's humanist educational reforms as Prussian minister of education (1809-1810), his founding of the University of Berlin, and his profound works in the theory of language.

But his younger brother, Alexander, was no stranger to the Weimar circle. He often visited, establishing especially close relations with poet and natural scientist Johann Wolfgang von Goethe, whose work on underlying form and structure in plants and animals, resonated strongly with Alexander's "Oneness Out of Manyness" methodology.[5]

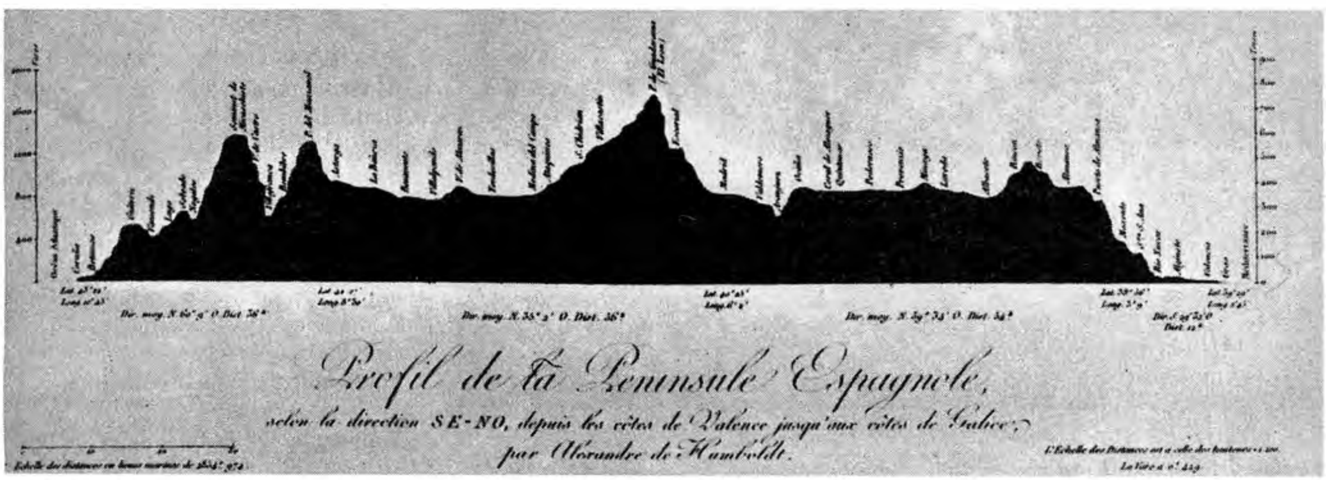
Much is made in shallow biographies of Humboldt, of a disparaging remark Schiller made of Humboldt in a letter to Schiller's intimate, Christian Gottfried Körner, in 1797. "His mind is that cold, dissecting kind that wants all nature to be shamelessly measured," Schiller wrote, ". . .when Nature must be seen and felt in its single manifestations and highest laws. With unbelievable impertinence he uses his scientific formulae, which are nothing but empty words and narrow concepts, as a universal standard."

Körner's response was a fitting rebuke to Schiller's misappraisal.

> His [Humboldt's] striving to measure and anatomically dissect [*anatomieren*] everything, rests on sharp obser-

Archiv für Kunst und Geschichte, Berlin

The Humboldt brothers were among Schiller's circle of friends at Jena. Here, an illustration of Schiller (right) entertaining in his garden. Alexander Humboldt (at balcony) with Goethe (back row, left) and his brother Wilhelm (back row, third from left).



From *Atlas géographique et physique du Nouveau Continent*, by Humboldt and Bonpland

Humboldt measured and recorded the altitude of the Spanish Peninsula, during his six-week walk to Madrid, across the Pyrenees. He was the first to note that the interior of Spain is a plateau. This "cross-sectional" method of showing broad swaths of topological features was a Humboldt innovation.

vation, and without this, there are no useful materials for the investigator of Nature.... Meanwhile, he indeed seeks to order scattered materials, into a Whole, pays attention to the hypotheses which expand his view, and gives rise thus to new questions regarding Nature.

Wilhelm's appropriate observation regarding his brother, was that "Alexander really attempts to embrace all in order to explore one thing, which can be done only by approaching it from all sides. He maintains a horror of the single fact."

Humboldt was then, and for the rest of his life, locked in combat with exactly the empiricist ("just the facts, ma'am") school of Bacon, Hobbes, and Hume; just as he would become locked in combat with the other extreme, the German Romantic "philosophers of nature," who rejected quantification and strict measurement, and extolled feelings and intuition as the source of true knowledge of the natural world. This latter school, exemplified in the work of F.W. Schelling (1775-1854), became known for such statements as "Forests are the hair of the animal earth"—not too different from the Gaia thesis today.

If Schiller disparaged Humboldt on this occasion (although Humboldt was also the only scientist invited to contribute an essay to Schiller's philosophical journal, *Die Horen*), there can be no doubt of Humboldt's keen absorption and appreciation of Schiller's outlook and genius. In the introduction to *Cosmos,* Humboldt describes the origins of what he calls a "philosophy of nature," in terms which uncannily echo Schiller's *Letters on the Aesthetic Education of Man:*

Reproduced from Douglas Botting, *Humboldt and the Cosmos* (London: Sphere Books Ltd., 1973), p. 60

Aimé Bonpland in an illustration by Pellegrini at the National Museum of Natural History in Paris.

> An intimate communion with nature, and the vivid and deep emotions thus awakened, are likewise the source from which have sprung the first impulses toward the worship and deification of the destroying and preserving forces of the universe. But by degrees, as man, after having passed through the different gradations of intellectual development, arrives at the free enjoyment of the regulating power of reflection, and learns by gradual progress, as it were, to separate the world of ideas from that of sensations, he no longer rests satisfied merely with a vague presentiment of the harmonious unity of natural forces; thought begins to fulfill its noble mission; and observation, aided by reason, endeavors to trace phenomena to the causes from which they spring.

Painting by Friedrich Georg Weitsch, 1810, courtesy of Archiv Preussicher Kulturbesitz

Humboldt and Bonpland before their climb of Ecuador's Mt. Chimborazo, 20,577 feet, at the time thought to be the world's highest mountain. Even though they came 700 feet short of the summit (they measured their altitude with sophisticated barometric readings), it remained the world record in mountain climbing for 30 years and earned Humboldt enduring popular acclaim worldwide.

Humboldt dedicated one of his volumes of botanical researches in the Americas, to Goethe; and he dedicated his book on Columbus and the Rediscovery of America, to Schiller. It was with a line from a poem by Schiller, "Der Spaziergang" (The Walk) of 1795, that Humboldt summarized a crucial point in *Cosmos:*

> Here we touch upon the point, where, in contact with the sensuous world, the stimuli to pleasure are joined to a different kind of enjoyment, an enjoyment which springs forth from Ideas. That which in the strife of the elements, is not perceived as ruled by order and lawfulness, becomes subject to reason. And man, as the immortal poet [Schiller] says, "seeks the immobile Pole in the flight of appearances."[6]

Training by the Ecole Polytechnique

In 1796, Humboldt's mother died (his father had died years before, when he was 10), and he was left with a substantial inheritance. Though his career in mining administration offered prestigious prospects, he resigned all his posts and dedicated himself to preparations for world travel—wherever an opportunity should open up for the ambitious scientific bent he had had since childhood. Throughout 1797, he trained with the best botanists and geologists of Central Europe; in 1798, his road led to Paris where his brother, Wilhelm, had been dispatched as Prussian envoy. In Paris, Alexander gave lectures on his own considerable researches and writings,[7] met the leading figures of French science (those who had not embarked for Egypt with Napoleon that year), and even joined the French geodetic survey team working on the triangulation measurements of the Dunkirk-Barcelona meridian line (passing through Paris), which later served as the basis for establishing the length of the meter (one 40-millionth of the Paris meridian).

University of Pennsylvania Library

Fausto Elhuyar was one of an extraordinary cadre of scientists and mining engineers recruited by the pro-American faction in the Spanish Court, and sent to Spanish America to unleash a Franklin-style scientific and economic revolution. Another in this circle, Manuel del Río, was Humboldt's classmate at the Freiberg Mining School, and hosted Humboldt in Mexico in 1803.

It was during the summer of 1798, that Humboldt received an invitation that seemed sent from heaven: One of his childhood heroes, Louis Antoine de Bougainville, celebrated for his circumnavigation of the globe a generation earlier, had received a mandate from the Directory that then ruled France, to organize a five-year scientific exploratory mission, which would make extensive stops in South America, the South Pacific, Southeast Asia, the east coast of Africa, and even Antarctica. Bougainville asked Humboldt to join it. Because departure was imminent, the ecstatic Humboldt plunged into a whirlwind of training in the use of the most advanced instruments that the scientists of the Ecole Polytechnique had available, some of which—telescopes and magnetometers—featured new designs and capabilities.

But the project was postponed at the last minute, as a result of French preparations for war with Austria. Humboldt was left high and dry. He had met a capable young botanist, however, Aimé Bonpland, and the two of them set out to explore ways to get into the Near East through southern France. When that looked too dangerous, they set off on foot to Spain.

Drawing of Don José Celestino Mutis by Fernandez, at the Cadiz Museo Iconografico; reproduced from Douglas Botting, *Humboldt and the Cosmos* (London: Sphere Books Ltd., 1973), p. 147

José Celestino Mutis, the "Linnaeus of South America," was Humboldt's host in Nueva Granada (today, Colombia). A master botanist and astronomer, he was the most eminent of the scientific cadre dispatched by Charles III to the New World.

Breakthrough in Spain

The way in which Humboldt suddenly found the patronage, in the court of Spanish King Charles IV, to undertake his mammoth five years of travel through what is today Venezuela, Colombia, Ecuador, Peru, Mexico, and Cuba, is glossed over in virtually every biography as just a lucky break. As the story goes, the envoy of Saxony to the court of Aranjuez managed to get a good word in for Humboldt with the Foreign Minister, Mariano Luís de Urquijo, who in turn bent the ear of the King, and that was that.

In fact, Humboldt's arrival had been seized upon as providential by a group of Spanish notables who had been collaborating with Franklin and his allies for the previous 30 years, and had sponsored an enormous *scientific mobilization of the best minds in Spain and the colonies* throughout that time. They were on the defensive at the time of Humboldt's arrival; his mission would revive, and focus all their previous efforts.[8]

Spain had begun economic renewal when the French Bourbons became Spain's ruling house at the beginning of the 18th Century. By mid-century, the work of Jean Baptiste Colbert, the great exponent of industry and national development under France's Louis XIV, had been fully translated into Spanish, and a school of National Economy was forming. Charles III, who reigned 1759-1788, was the greatest of the Bourbon kings. He tilted Spain toward the American cause in the American Revolution, and sponsored a Commonwealth policy toward the Spanish American colonies, which was designed to break the grip of feudalist interests within Spain, by mobilizing a scientific and economic breakout in the colonies.

His leading ministers included:

• The Count of Aranda, sent by Charles as Spanish ambassador to France during the years of the American Revolution. Aranda met Franklin, sealed Franco-Spanish cooperation for the American cause, and even sent arms to the colonists' side;

• Pedro Rodríguez de Campomanes, who became a correspondent of Franklin's American Philosophical Society at the end of Charles's reign;

• José de Gálvez, Charles's Minister for the Indies who abolished the *repartimiento,* a form of de facto slavery for the Indians, in 1776, year of the American Declaration of Independence. Gálvez's nephew, Bernardo de Gálvez, took up arms for the American cause; Galveston, Texas, is named for him.

The Great Expeditions

Charles and his ministers sent wave after wave of scientists and expeditions into the Spanish colonies.

Humboldt's Travels in South and Central America

Humboldt and his botanist co-adventurer, Aimé Bonpland, left Spain from the port of Coruña on June 5, 1799, dodging British warships blockading the coast. They returned to Europe via the French port of Bordeaux just over 5 years later, August 3, 1804. Whatever itinerary they had in mind at the start, it soon vanished in the labyrinth of accident and happenstance which dominated their actual route of travel. Alongside their multi-faceted scientific accomplishments, it was their cheerful handling of dramatic hazards, discomforts, and setbacks (they were reported dead on repeated occasions in various U.S and European newspapers), that made their travels such a sensation to the European and North American public at the time.

June 1799 to December 1800: Venezuela

After a stopover in the Canary Islands, Humboldt's ship headed to Cuba. But typhoid broke out on board as the ship neared the South American coast, and a panicked captain put in at Cumaná, Venezuela. From this abrupt change of plans, Humboldt and Bonpland seized the opportunity, over the next 16 months, of travelling across 1,500 miles of interior Venezuela, and collecting close to 5,000 plant specimens, 3,000 of them unknown to European botany. Among the phenomena Humboldt studied closely was the use of natural rubber and the physiology of the electric eel. He brought the poison, curare, back to Europe for the first time.

Their travels, after crossing the vast llanos (savannahs) of interior Venezuela, carried them to the spectacular hydrographic anomaly of the Casiquiare, a natural canal joining the Orinoco River of Venezuela with the Rio Negro of the Amazon basin. Here Humboldt observed petroglyphs high on a bluff overlooking the Rio Negro, which first prompted his fascination with pre-Columbian civilization and his conviction that, far from originally being primitive peoples, the tribes of the New World represented degenerated higher societies that had had maritime trans-oceanic contact.

Humboldt made careful observations of astronomical singularities, (including a solar eclipse of October and a meteor shower of November 1799, one of the greatest on record), along with precise observations of an earthquake, and extended notations on what he called "atmospheric tides": a rise and fall in temperature and barometric readings in four oscillations every day at exactly the same times, at complete variance with normal daytime heating. ("The mercury falls from 9 o'clock in the morning until 4 o'clock in the afternoon. Then it rises until 11 o'clock, falls again until 4:30, rises until 9 o'clock.")

December 1800 to March 1801: Cuba

After a perilous 25-day voyage, Humboldt and Bonpland disembarked in Havana, Cuba, the "pearl of the Spanish Antilles." It was also the slave-trade capital of the region, run largely by the British, and Humboldt collected statistics which constituted one of the most devastating indictments of slavery ever assembled. "It would be easy to prove," Humboldt later wrote, "that the whole of the West Indies, which now comprises scarcely 2,400,000 Negroes and mulattoes (free and slaves), received from 1670 to 1825 nearly 5,000,000 Africans. These revolting calculations regarding the consumption of the human race do not include the number of unfortunate slaves who perished on the passage or were thrown into the sea as damaged merchandise." Humboldt excoriated the Adam Smith British school by name, for portraying this "greatest of all evils", as a "universal benefit."

Humboldt planned next to head up to the U.S. Great Lakes, descend and map the Mississippi, cross over Mexico, and head out to the Philippines. But just at that moment a newspaper account reached him, saying that the French expedition which had almost sailed with Humboldt aboard from France two years previously, had been reconstituted under a Captain Baudin, and was under sail for South America and the South Seas. Humboldt resolved to meet up with it in Lima, Peru. So he headed back to the South American mainland.

March 1801 to March 1803: The Andes

Upon arriving in Cartagena, Colombia, the two travellers embarked on what eventually stretched out to two years of travel along the "Spine of South America," the great corridors of volcanoes called the Andes. Here flourished Humboldt's insights and researches into plant geography, volcanic phenomena of all sorts (he broke definitively with the "Neptunist" school of geology, which argued that all rock formation was fundamentally sedimentary), and the multi-faceted history, archaeology, and ethnography, of the Indian civilizations. He also mastered high-altitude mountain climbing and set a world climbing record on the slopes of Chimborazo, in Ecuador, not surpassed anywhere in the world for 30 years.

It was in Quito, in June of 1802, that word reached Humboldt that the effort to catch up with Baudin's expedition was in vain; Baudin had turned east in the South Atlantic, to circumnavigate the globe by way of Africa, rather than west, via the Pacific coast of South America.

After their mountain-climbing exploits, the travellers continued south, crossing over the Andes Cordillera into the headwaters of the Amazon for a short time; and then re-crossing at Cajamarca, where Humboldt watched the needle of his compass turn from North to South: It was the first ever determination of an exact value (in the dip of the needle) for the "magnetic equator," and it would serve as a world gauge for magnetic measurement for 35 years.

Soon after, in the mountains above Trujillo, Peru, the travellers caught their first glimpse of the Pacific. Two dreary months in Lima were largely spent packing and shipping their collections to Mexico and Europe, but Humboldt took advantage of the time to make observations of a transit of Mercury across the Sun, to accurately set the longitude of Lima's port, Callao, for the first time.

Humboldt resolved to proceed to the most developed of the Spanish possessions in the Americas, New Spain (Mexico). Heading to a stopover in Guayaquil, Ecuador, by ship, he made measurements of the great northward-flowing cold current of that part of the South American coast, from then on known to world geography as the Humboldt Current—despite Humboldt's own repeated protestations that he in no way had discovered it, but only investigated it.

March 1803 to April 1804: Mexico

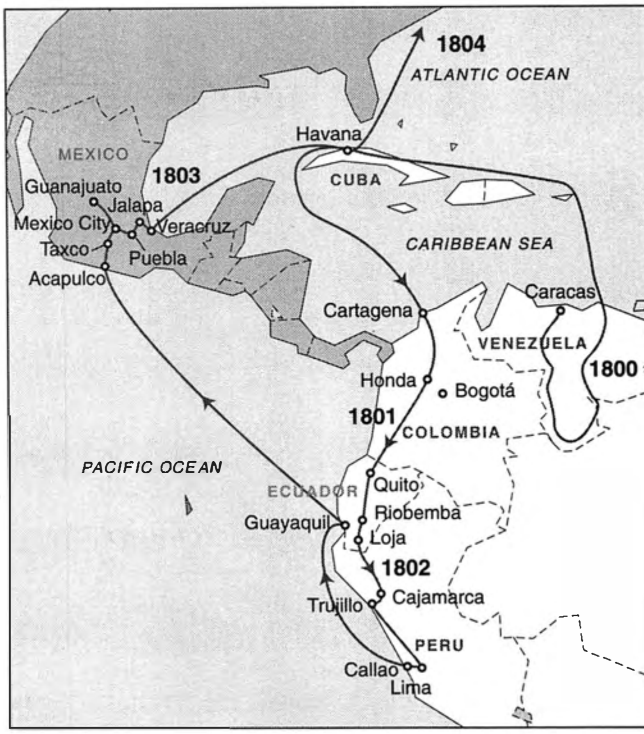
Humboldt and his companions (Carlos de Montúfar, the son of the Provincial Governor of Quito, had joined the expedition in the Andes) travelled relatively little in Mexico, in relation to the great distances of the earlier phases of the expedition. But Humboldt carried out the most thorough research of the entire journey, with unprecedented access to all the archives of the vice-royalty concerning natural resources, administration, income and expenditures, and much more. His personal tours took him to the centers of mining in Taxco, Real del Monte, and Guanajuato, in the company of his old friends from the Mining School of Freiburg.

And he could not pass up personal inspection of Mexico's great volcanoes, including the Jorullo volcano which had begun to surge upward from some cornfields only 40 years before. The result was a treatise in political geography which set a world standard for such writing at the time, *Political Essay on the Kingdom of New Spain*.

April 1804 to August 1804: Cuba and the United States

Humboldt had planned to continue westward from Mexico, to complete a circumnavigation of the globe. But instead, he headed back to Europe. His reasons, as expressed in a letter of the time: "The damaged state of our instruments, the futility of our efforts to replace them, the impossibility of meeting Captain Baudin, the lack of a ship that could bring us to the enchanted islands of the South Pacific, but, above all, the urgent need to keep pace with the rapid advancement of science which must have taken place during our absence, these are the motives for the abandonment of our project of returning via the Philippines and through the Red Sea to Egypt. . . ."

Instead, after a short repeat stop in Havana, he detoured to see his admired United States of America and its President, Thomas Jefferson. He would finally set sight on European shores again, August 3, 1804.

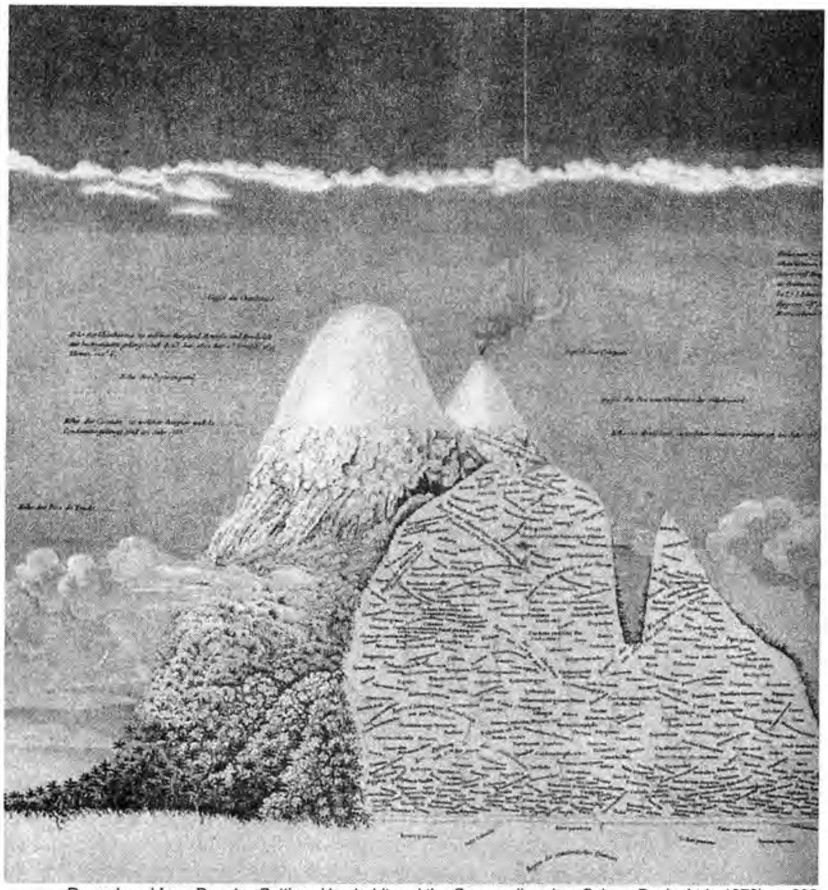


HUMBOLDT'S TRAVELS IN THE AMERICAS

Perhaps the most famous of these scientists was the monk José Celestino Mutis, sent to Bogota, capital of Nueva Granada (what is today Colombia, Venezuela, and Ecuador) in 1763. He became the pre-eminent botanist of the hemisphere, corresponding avidly with Linnaeus in Sweden, perfecting the study and the painstaking painting of botanic specimens, and founding the first astronomical observatory in Spanish America. In 1783, he led the legendary Expedición Botánica of the flora of northern South America, the largest such enterprise of its time. Usually forgotten, however, are two large-scale, companion botanical expeditions sponsored by the Spanish crown at the same time, the Ruíz-Pavón expedition to study plant life in Peru and Chile, and the expedition of Dr. Martín Sesse to Mexico, California, and Guatemala.

Humboldt was to pivot his work in Nueva Granada around an extended stay as Mutis's houseguest in 1801. He would befriend and correspond with Mutis's greatest protégé, Francisco José de Caldas.

No less notable was the Spanish crown's promotion of improved mining techniques, and the sciences of geology and metallurgy. Exemplary was the deployment of the two Elhuyar brothers, Fausto and José. Born in Spain of German parents, the brothers were sent in 1778 by the Count of Aranda to Paris, Mannheim, and Leipzig, to study the most advanced earth sciences of the time. Their researches in Upsaala, Sweden, in 1781 resulted in the discovery of tungsten, which brought the brothers renown throughout Europe. In 1785, Charles commissioned Fausto to organize a mission of German scientists and miners to introduce advanced mining techniques to all the colonies. Fausto was named the director general of Mexico's Royal Mining Corps in New Spain. By the time Humboldt reached Mexico in 1803, Humboldt's classmate at the



Reproduced from Douglas Botting, *Humboldt and the Cosmos* (London: Sphere Books Ltd., 1973), p. 208

Humboldt's profile of Mt. Chimborazo, showing different plants at different altitudes.

Freiburg mining school in 1792, Manuel del Río, had assumed the directorship.

Fausto's brother, José Elhuyar, was assigned to Peru, where he installed a team that included German botanist Count Nordenflict—Humboldt's hosts and collaborators when he reached Lima in late 1802.

All of these networks were, in turn, directly tied into Franklin and his American Philosophical Society. One of Franklin's little-known accomplishments is that he was a leading Hispanist, interested in encouraging companion republican currents in Spanish America. Franklin made a point of forming an extensive collection in Philadelphia of the writings of Spanish American scientists and intellectuals. Leading figures throughout the continent tirelessly sponsored the return flow of Franklin's works and those of the Philosophical Society to Spanish America, notably through Antonio Alzate's *Gazeta de Literatura* in Mexico, José de Caldas's *Semanario* in Bogota, and José Hipólito Unanúe's *Mercurio Peruano* in Lima. Alzate, the naturalist known as Mexico's first experimental scientist, translated and published Franklin's works on heat rays, optics, and waves, and later became an official correspondent of the American Philosophical Society.

In the succeeding years, Humboldt personally aided in getting papers, journals, and letters, of prominent U.S. figures, into Mexico, Caracas, Bogota, and Lima.

The Philadelphia High Point

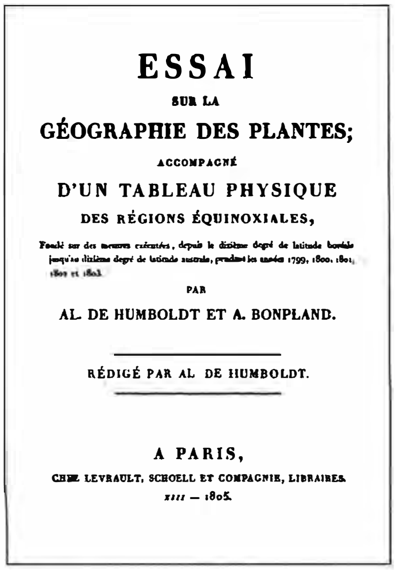
A high point in Humboldt's five years of travels was Franklin's Philadelphia itself, where he arrived in May of 1804. After writing President Jefferson that "for moral reasons, I could not resist seeing the United States," and requesting a meeting with the President, Humboldt threw himself into a dizzying round of meetings and activities with the surviving core of Franklin's collaborators at the American Philosophical Society, which Franklin (1706-1790) had founded in 1743. Humboldt's enthusiastic hosts included Dr. Benjamin Rush, eminent physician and signer of the Declaration of Independence; Dr. Benjamin Smith Barton, America's foremost botanist and an authority on American Indian culture; Dr. Caspar Wistar, holder of the chair of anatomy at the Franklin-founded University of Pennsylvania, and the foremost authority on fossils in America; and Andrew Ellicott, one of America's leading astronomers and mathematicians, based in Lancaster, Pennsylvania. Humboldt was elected a member of the Society on the spot, and sat for a full portrait by the celebrated Dr. Charles Wilson Peale.

Rush, Barton, Wistar, and Ellicott had all personally trained Meriwether Lewis exactly one year before, on the techniques of mapping, botany, astronomy, and medical science which Jefferson had mandated that his personal secretary receive before leaving on the famed Lewis and Clark Expedition. Lewis and Clark were already headed up the Missouri River on the first leg of their three years of travels when Humboldt arrived in the United States. If Humboldt's accounts of his travels and studies in Central and South America seemed heaven-sent to the Franklin Philadelphians who thrilled to Lewis and Clark's mission of unveiling the western continental expanses, even more did it appear so to the author of the Expedition himself, President Thomas Jefferson. Jefferson enthusiastically invited Humboldt to the White House for detailed conversations and consultations.

A Bountiful Scientific Harvest

Humboldt had left for the New World with no less than 40 crates of instruments. They were of the most advanced designs then available from the Ecole Polytechnique in Paris, and Humboldt was a master in their use.[9] Some of the descriptions Humboldt provided of his travels are at once hilarious and harrowing—one of the reasons for his great popular acclaim in later years.[10] But Humboldt's interaction with the Charles III-Franklin currents in Spanish America, produced an explosion of measurements and hypothesis, one of the great scientific treasure-harvests of all history.

Among his most notable achievements, developed in the 30 volumes which he either wrote, or had others elaborate, based on his and Bonpland's researches, are these:


ESSAI

SUR LA

GÉOGRAPHIE DES PLANTES;

ACCOMPAGNÉ

D'UN TABLEAU PHYSIQUE

DES RÉGIONS ÉQUINOXIALES,

Fondé sur des mesures exécutées, depuis le dixième degré de latitude boréale jusqu'au dixième degré de latitude australe, pendant les années 1799, 1800, 1801, 1802 et 1803.

PAR

AL. DE HUMBOLDT ET A. BONPLAND.

RÉDIGÉ PAR AL. DE HUMBOLDT.

A PARIS,

CHEZ LEVRAULT, SCHOELL ET COMPAGNIE, LIBRAIRES.

XIII — 1805.

The title page from Humboldt and Bonpland's Essay on the Geography of Plants, published in Paris in 1805. Humboldt brought a new richness and breadth to the understanding that an increase in altitude mimicked the changes in climate, flora, and fauna of latitudes advancing to the poles.

• He developed the first graphic representations of cross-sectional altitude readings for large land masses.

• His writings and graphic schema presenting the spatial distribution of flora according to ecological zones, were revolutionary (see his illustration of the intricate mosaic of plant zones on the rising slopes of Ecuador's highest peak, Chimborazo, p. 22). He made more precise the insight that rising altitude in the tropics, mimicked increasing latitude toward the poles: Travelling 50 miles from the coast of Ecuador up to the top the Andes, was the equivalent, in terms of plant and animal zones, of travelling 5,000 miles to the north or south.

• Humboldt first developed the theory and rigorous use of isotherms and isobars, to present geographically extensive temperature and barometric readings over time.

• Among hundreds of other crucial geomagnetic readings, his discovery of the "magnetic equator" in Cajamarca, Peru (where the needle on his magnetometer swung from north to south), gave a root value for geomagnetic scalar measurements adopted worldwide until Gauss's development of an absolute scalar magnitude in laboratory conditions in the late 1830s. Gauss pored over the rich bounty of Humboldt's measurements; the two of them would later collaborate in setting up the first international organization for collecting geomagnetic data, the *Magnetische Verein* (Magnetic Union).

Humboldt equally opened up fruitful lines of *historical and cultural* investigation. He awakened Europe to the fact that pre-Columbian civilizations were advanced civilizations; that seemingly "primitive" peoples could well reflect merely the degeneration of previous higher cultures; that transoceanic contact, particularly between Asia and the Americas, was likely in periods reaching back many thousands of years. He rehabilitated the figure of Columbus, as a supreme navigator and explorer, while the "Enlightenment" salons of the time were denigrating the spread of Renaissance modes of statecraft and science as viciously as such modes are denigrated today.

Return to a Europe at War

Humboldt was 34 when he returned in 1804 from his five years of travels in the New World. He returned to a Europe which had pitched into war while he was gone, and which would not emerge from it for 10 long years more. After the Congress of Vienna in 1815, the reactionary regimes installed by Britain and Metternich's minions throughout continental Europe, were directed to crush any activity consistent with the ideals and example of the struggling United States republic.

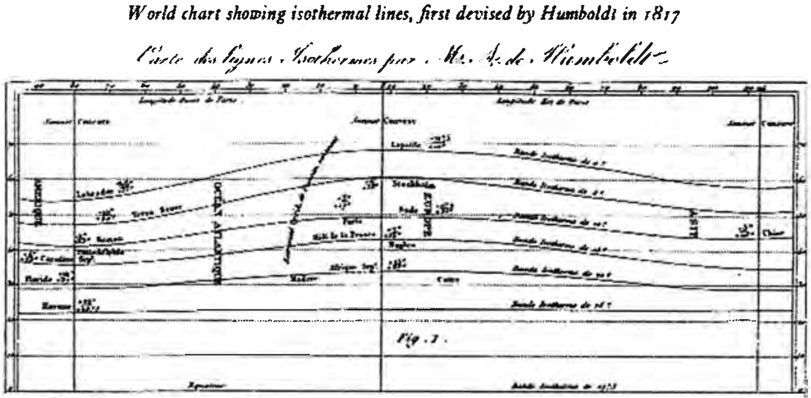
Humboldt had been lionized throughout Europe for the exotic locales and daring of his explorations (newspapers had reported his death many times over). He chose to make Paris his headquarters for the next 23 years, despite the imputation of disloyalty to Prussia it brought on him during the Napoleonic wars. But Humboldt needed the intellectual and institutional resources then concentrated in the Ecole Polytechnique circles of Paris to bring out his stupendous 30 volumes of the scientific and cultural discoveries of his travels.

Humboldt himself addressed a specially convened meeting of the Institute of France a few months after his return to Europe, and boldly proclaimed:

> I aim at collecting ideas rather than material objects. A private person who with moderate means undertakes a journey round the world, has to confine himself to matters of major interest. To study the formation of the Earth and its strata, to analyze the atmosphere, to measure with sensitive instruments its pressure, temperature, humidity, the electric and magnetic charge, to observe the influence of the climate on the distribution of plants and animals, to relate chemistry to the physiology of organized beings, there are the aims I have proposed to myself.[11]

Humboldt carried out his aims by publishing the results of his travels, including 1,425 illustrations and maps, many

World chart showing isothermal lines, first devised by Humboldt in 1817



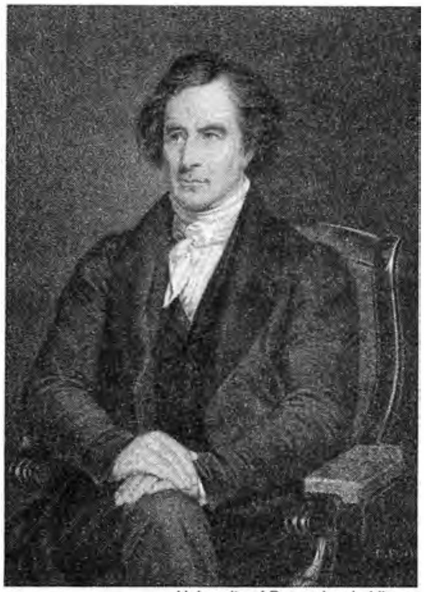
Reproduced from Douglas Botting, *Humboldt and the Cosmos* (London: Sphere Books Ltd., 1973), p. 209

Humboldt devised the concept of isothermal lines, a chart connecting equal mean temperatures, as a way of comparing different climate conditions around the world.

hand-colored. The effort cost Humboldt his entire remaining personal fortune.

Why Paris? It was a question his brother, Wilhelm, would pointedly ask as the Prussian Wars of Liberation against Napoleon's armies commenced after 1808, and Wilhelm's own son, Theodore, eventually went to the front lines. Why was Alexander in the enemy's capital?

Napoleon had styled himself a patron of science and had the means to keep the scientific institutions of France more richly endowed than they were in any other country of Europe at the time. But despite this nominal flourishing of science, there was in fact a campaign against *the key figure of republican statecraft and science, Lazàre Carnot* (1753-1823), the Ecole Polytechnique founder and "Architect of Victory" in saving France from invading armies in 1794. Nothing exemplified this more clearly than the election of members of the Institute of France's "First Class" Division in 1799. Carnot had been summarily expelled, and consigned to virtual internal exile for the next 15 years; Napoleon arranged to have *himself* elected to Carnot's vacant chair!


University of Pennsylvania Library

François Arago, Humboldt's great ally and close personal friend, in the French Ecole Polytechnique tradition. Humboldt and Arago, together with Fresnel and Ampère battled the stifling Newtonianism of Napoleon's scientific toadies.

Further, the Institute and a smaller steering committee that controlled all patronage in the French scientific establishment, the Arcueil Society, were run by a mafia of Napoleon sycophants and diehard Newtonians, headed by chemist Claude Louis Berthollet and astronomer Pierre-Simon Laplace (1749-1827).[12]

But Humboldt's genius was to use the facilities afforded in Paris (he became a full member of the Arceuil Society, and in 1810, a Foreign Associate of the Institute of France), to consolidate his own scientific eminence, while sponsoring scientific circles in both France and Germany that would break the noose of Enlightenment Newtonianism, and reassert the Cusa-Kepler-Leibniz method.

'You Are Interested in Plants, Monsieur?'

Certainly there was no love lost between Napoleon and Humboldt. In a famous meeting just before Napoleon was crowned as emperor in December 1804, Napoleon turned to him and asked, "You are interested in plants, monsieur?" Humboldt replied that he was. "Well, so is my wife," was Napoleon's curt reply before he turned away.

In 1810, Napoleon ordered Savary, the Minister of Police, to expel Humboldt from Paris within 48 hours, on suspicion of being a Prussian spy. The order was rescinded through the intercession of Interior Minister Chaptal.

Through most of his first decade in Paris, Humboldt lived in rooms at the Ecole Polytechnique. His closest circle of associates, one generation younger than he, were all among the first graduating classes of the Ecole (founded 1794), when Carnot's personal role was the greatest. Among these were the chemist Joseph Louis Gay-Lussac (1778-1850), and, especially important, Dominique François Arago (1786-1853).[13]

It was Arago's work, first with Augustin Fresnel (1788-1827) in the establishment of the wave theory of light, and then with André-Marie Ampère (1775-1837) in the development of electromagnetism, which overthrew the Newtonian straitjacket of the Arcueil circle and kept fundamental science alive in France during the Restoration.

Similarly, in Germany, Carl Friedrich Gauss (1777-1855) had reasserted Kepler's method over Newton's in his famous 1801 calculation of the orbit of the asteroid Ceres. As Arago was Humboldt's great collaborator and intimate friend in Paris, in the face of constant political and scientific hostility (Arago's republicanism was even more intransigent than Humboldt's), so was Gauss in Germany, where both faced the same hostile underlying conditions after 1815. In Humboldt's failed attempt to secure Gauss a professorship at the University of Berlin in 1824, Humboldt revealed that he had first intervened on Gauss's behalf with the King of Prussia as early as 1804. In 1827, Humboldt wrote Gauss, that a significant motivation for his decision to leave Paris and establish Berlin as his base of operations, was "the prospect of living near you and being able to join those who share my admiration for your great and varied talents. . . ."

In 1837, when Gauss's son-in-law was one of the "Göttingen Seven" professors expelled by order of the British overlords of the Brunswick Duchy, Humboldt stepped in quietly to eventually arrange Berlin University appointments for four of them. Humboldt's own mail was opened and his movements surveilled by secret political police in both the 1820s, in Paris, and in the 1840s and 1850s, in Berlin. Finally, he took to writing his most intimate comments in Hebrew or Sanskrit!

How precarious the survival of republican science was in these years, and how crucial Humboldt's personal role in saving it, is captured in two incidents from the period of the Napoleonic wars. In the winter of 1806-1807, after Napoleon had secured a crushing victory over the Prussian armies at Jena, and the Prussian court had fled to the east, Humboldt interceded with the French authorities on behalf of the University of Halle, which Napoleon wanted to destroy as punishment for the patriotic passions of its students, and, at the last moment, saved the university. The tables were turned seven years later, when the Allies triumphantly entered Paris in early 1814; it was Humboldt who interceded with the Prussian authorities, to save the French Museum of Natural History from being ransacked.

'From King to Bricklayers'

By the late 1820s, Humboldt had gathered such personal renown that he believed he could defy the post-Napoleon, Restoration repression of the republican development of science. In 1827, he returned to Prussia and immediately launched one of the cultural coups of the age. Within a few short months, he had organized a series of public lectures in one of the most prestigious halls in Berlin, the Singakademie, based on a concurrent, more extensive lecture series limited to Berlin University. The first of these 16 weekly lectures took place December 6, 1827, before a packed house that included members of the royal house, merchants, students, and—in a complete innovation for the time—women. Contemporary chroniclers exclaimed how everyone, "from King to bricklayers," was there.

That he set out to create a quality of citizenry that would be a medium for the defense and transmission of scientific progress, was already his declared aim from 30 years earlier. In a letter written by Humboldt to a friend, Johann Gabriel Wegener, in 1789, he declared:

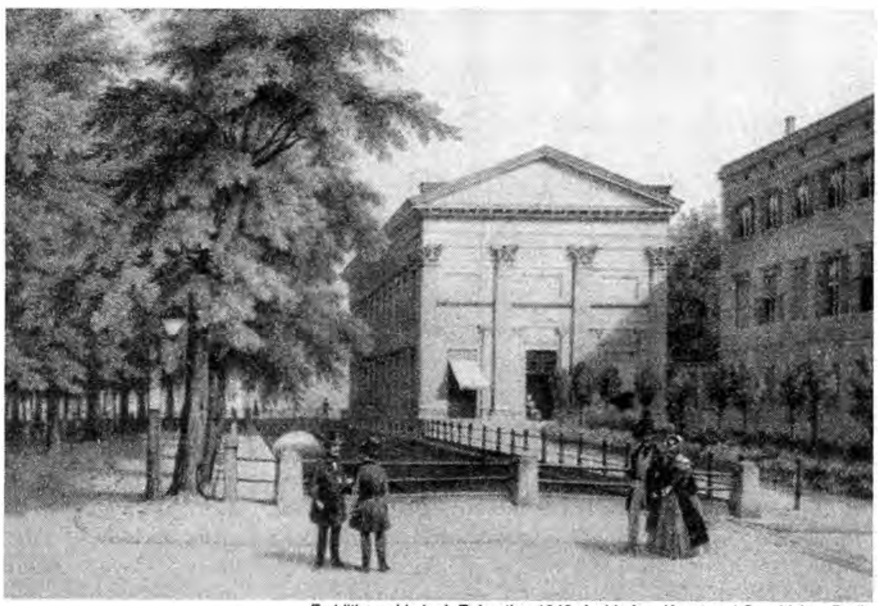
> I'm just coming back from a walk in the zoo. Quite surrounded by purest, the most innocent joy of thousands of creatures, who (happy memory of Leibniz's philosophy!) joy in their existence. . . . Would you believe it, that among the other 145,000 people in Berlin, there are hardly four to be found who cultivate this part of natural science—even if only as a hobby, for recreation. And for how many should this not lead to a vocation or profession, doctors and especially miserable students of economics. When population increases, and along with it, the price of consumer goods, when the people end up shouldering the burden of a shattered economy, all the more should we think about opening up new sources of food supplies for satisfying the wants afflicting us from all sides. Every day we tread on "resources" which we now import from distant parts of the world, until someone discovers them, after many decades, by accident; but then someone else comes along and buries the discovery again, or more rarely, spreads it widely. Everywhere I see the human understanding sunk in some error, everywhere he believes to have found the truth, and imagines that there is nothing left for him to improve, nothing left to discover. . . . This is true in religion, in politics, everywhere that popular opinion rules. . . . No, the great discoveries, which I myself have found buried in the writings of biologists from antiquity, which have been verified in modern times by learned chemists and technologists, have brought these thoughts to my mind. *What is the use of any discoveries, if there is no way to make them intelligible for the uninitiated* [emphasis added].[14]

Now, standing on the stage of the Singakademie, Humboldt developed the theme of the lectures in uncompromising words later set down in his great work, *Cosmos:* "In claiming the unity of the human race, we resist the unsavory assumption of higher and lower races." Some peoples are more exposed than others to education and "cultural ennoblement," but "there are no inferior races. All are destined equally to attain freedom."

It should not be surprising that the opposing view, typified by Charles Darwin, could not make headway in the 30 years in which the force of ideas launched by Humboldt in his Berlin lectures, and consolidated by the publication of *Cosmos,* took Europe by storm. Darwin only released his *On the Origin of Species, by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life,* in 1859, the year of Humboldt's death.

Humboldt's first lecture was on the ancient Greeks' view of the interdependent order of things, *Kosmos.* The second lecture, was on the contributions of the Arab renaissance. In a radical departure from conventional "descriptive geography," which took the surface of the Earth as its domain, Humboldt launched into a full description of the phenomena of the heavens as well. He dwelt on the then-newly-discovered phenomenon of double stars, the latest results of astronomical optics and interference phenomena, volcanoes on the Moon, meteors, and sunspots. His aim was truly to integrate the cosmos: In the work that the lectures gave birth to, he would write,

> By uniting, under one point of view, both the phenomena of our own globe and those presented in the regions of space, we embrace the limits of the science of the cosmos, and convert the physical history of the globe into the physical history of the universe.



Farblithograhie by L.E. Luetke, 1842, Archiv fuer Kunst und Geschichte, Berlin

Humboldt's 1828 lectures at Berlin's Singakademie were a revolution in statecraft. He was committed to imparting a passion for scientific inquiry to the humblest levels of society, and forging a citizenry around the appetite for scientific progress.

In *Cosmos,,* which emerged 18 years later, Humboldt dedicates a substantial part of the second volume, to examination of how mankind's interest in the study of nature is stimulated (he takes the work of landscape painters, natural history writers, and the use of exotic plants in gardens as exemplars of this process), and concludes with a survey of "the diversity of the means by which mankind attained to the intellectual possession of a great portion of the universe."[15]

In such a "history of the physical contemplation of the universe," Humboldt urges close attention to "the prescient fancy and the vivid activity of spirit which animated Plato, Columbus, and Kepler," and then identifies a three-part subject of investigation:

> (1) The independent efforts of reason to acquire a knowledge of natural laws, by a meditative consideration of the phenomena of nature. (2) Events in the history of the world which have suddenly enlarged the horizon of observation. [Here Humboldt takes Alexander the Great's conquests, and the explorations of Columbus, as paradigmatic.] (3) The discovery of new means of sensuous perception, as well as the discovery of new organs by which men have been brought into closer connection, both with terrestrial objects and with remote regions of space.

Here Humboldt delves into the history of the development of the telescope, the microscope, the compass, and

> the different contrivances invented for measuring terrestrial magnetism; the use of the pendulum as a measure of time; the barometer; the thermometer; hygrometric and electromagnetic apparatuses; and the polariscope.[16]

In sum, he writes,

> The history of the civilization of mankind comprises in itself the history of the fundamental powers of the human mind, and also, therefore, of the works in which these powers have been variously displayed in the different departments of literature and art.[17]

Goethe's friend Karl Friedrich Zelter wrote to him of Humboldt's sensational lecture series at the Singakademie: "Before me stood a man of my liking who gives what he owns without knowing to whom, a speaker devoid of tricks and nebulous thoughts. . . ." Another correspondent of Goethe, Karl von Holtei, was equally dumbstruck:

> Eight hundred people hold their breath so that they might hear one person speak. There is no more lofty impression, than seeing earthly power paying homage to the spirit; and already on that account, Humboldt's current activity in Berlin belongs to the most sublime phenomena of the age.[18]

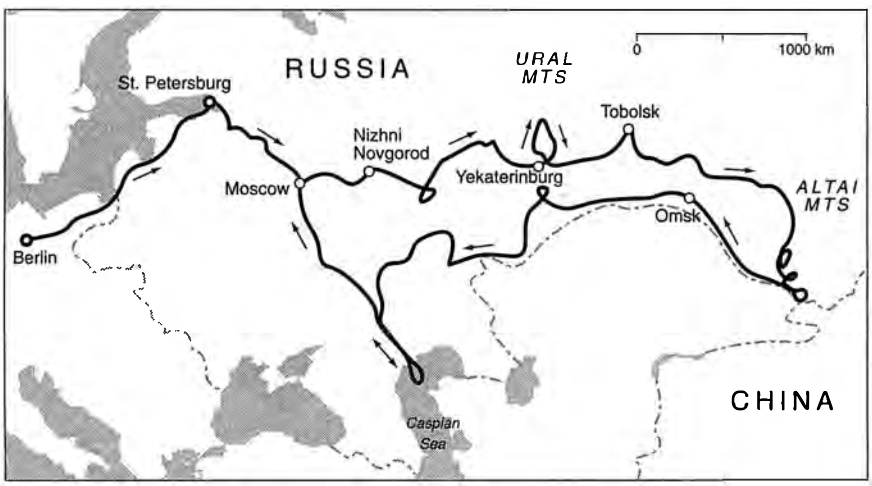
Return to America

During the period of the Napoleonic Wars and resultant constant sea blockades, there was little Humboldt could do to maintain his connection to the circles in the Americas he had so enthusiastically embraced. But the sentiments in his farewell letter to Jefferson in 1804, were never far from his mind. He had written then:

> I take leave in the consolation that the people of this continent march with great strides toward the perfection of a social state, while Europe presents an immoral and melancholy spectacle. I flatter myself in the expectation of enjoying this consoling experience again, and I sympathize with you in the hope . . . that humanity can achieve great benefit from the new order of things to be found here. . . .[19]

In the 1820s, he was able to reassert his personal commitment to the survival and prosperity of the new republics then emerging in all of the Americas. Humboldt's letter-writing energies were prodigious; he wrote as many as 3,000 a year, "dispatched to both hemispheres," as he stressed.

In 1821-1822, Humboldt was approached by a group of French financiers to act as their consultant on a large mining project in Mexico. Humboldt saw this as a springboard to larger



In 1829, Humboldt seized on an offer from the Russian government, finally to make a trip to the Central Asian heartland. He had eagerly sought backing from the British government, to visit the Indian subcontinent, cross over the Himalayas and the Hindu Kush, and thence into Russian Asia. Humboldt saw this as the Old World equivalent to the historic scope of his Spanish American travels, 25 years earlier. But the British were determined to prevent any Humboldtian projects which could undermine their colonial grip, and blocked his every request.

Humboldt's strenuous 5,000 miles of travel in one season, by carriage and boat, across the vast interior spaces of Russia, nevertheless yielded a rich storehouse of scientific knowledge, and foreshadowed the "Eurasian Land-bridge" development perspective of today.

things, and wrote his brother Wilhelm that the project

> . . .should prove useful for the best naturalists who, like myself, want to leave Europe. . . I have a big plan for a large Central Institute of Natural Science that would serve all of the liberated portion of America in Mexico. The viceroy will be replaced there by a republican government, and I have got it in my head to end my life in the most agreeable and, for science, most useful manner. . . . *This is my wish* [emphasis in original] . . . to gather a number of scholarly men around me, and *to enjoy the liberty of thought and feeling so indispensable to my happiness*. . . . You may laugh at my Mexican project, but owning neither family nor children, one should plan ahead on how to make one's old age as pleasant as possible. . . . All letters from Germany are censored.[20]

Political instabilities in Mexico, and a suspicious transfer of the mining syndicate to London, prevented the plan from coming to fruition. Humboldt instead shifted his energies to his return to Berlin, the launching of his "Cosmos Manifesto" at the Singakademie lectures, the hosting of 600 scientists at the first international scientific conference (a personal Humboldt project), and eight months of travel through Russian Asia.

NOAA Central Library

Alexander Dallas Bache in the field, ca. 1858. Bache, Franklin's great-grandson, was sent by America's beleaguered American System patriots to meet with Humboldt and Gauss, and reconnect America's scientific and educational direction with the Humboldt circle.

American Science: Humboldt and Bache

From the 1830s, until his death in 1859, Humboldt directed his energies in a very special way to nurturing a next generation of U.S. scientists and intellectuals, capable of reigniting the promise of the early years of the American Republic, which had briefly re-emerged during the Presidency of John Quincy Adams. Now, in the run-up to the American Civil War, this generation faced adverse home conditions, and Restorationist government in Europe, uniformly hostile to the survival of the American republic.

The best lens through which to see the character of this period, is Humboldt's relationship with Alexander Dallas Bache (1806-1867), Franklin's great-grandson. Bache—who had graduated first in his class from West Point in 1825, and would later become head of the U.S. Coast and Geodetic Survey, and founder and first president of the National Academy of Sciences—was dispatched by the American Philosophical Society circles to Europe for two years of travel, 1836-1838, to bring the scientific work and teaching methods of the Gauss-Humboldt circles to the United States. (On his return, he founded the first public high school in the United States south of New England, Central High School of Philadelphia, on these principles.) In all, Bache visited 278 schools in seven countries, at the same time touring mines, quarries, iron works, dye works, gas works, and other establishments of industry and infrastructure.[21]

Bache's first visit to Humboldt, in early 1837, is recorded in the briefest of entries in Bache's diary:

> I went to see Baron Humboldt by appointment. And spent nearly two hours during which the variety of ideas and subjects was actually overwhelming and I left him with a head-ache[!].

Humboldt put him in touch with the head of the Berlin Observatory to get better instruments for measuring terrestrial magnetism, and later, after Bache spent time with Gauss in Göttingen, Gauss personally designed some of these instruments.

In the keynote address to a special memorial session of the American Geographical and Statistical Society upon Humboldt's death in 1859, Bache conveys the deep influence Humboldt exerted over the intervening years:

> He loved to talk of the men he had met there [in Philadelphia, in 1804], and of the greatness of the country to which that city belonged. His scientific labors having been chiefly performed on this continent, he looked to this continent for his reward, and we feel that he was . . . almost an American.[22]

In the same address, Bache revealed that Humboldt and Arago had been instrumental in intervening to defend Bache's work at the Coastal Survey from political enemies in the United States in the mid-1840s.

Many Germans, fleeing the Prussia of the repressive Carlsbad Decrees to America, in the generation after 1815, brought Humboldt's writings and intellectual influence with them. With the opening of regular steamship travel between Europe and America in 1838, the trickle of Humboldt's American visitors going in the reverse direction, swelled to a stream. Among them were key figures in the group of American patriots acting as de facto intelligence agents on behalf of the besieged American republic, such as Samuel F.B. Morse and Washington Irving.[23]

While supporting Friedrich List's *Zollverein* (Customs Union) and the related pioneering railway construction plans of Beuth and Rother in Germany (winning over King Friedrich Wilhelm IV to von Krupp's revolutionary cast-iron steel process), Humboldt assisted the first stage of the great U.S. transcontinental railway construction project, later taken up under Lincoln: the route-surveying expedition carried out by Lt. A.W. Whipple.

The 'Common Property of Mankind'

> Each age dreams that it has approximated closely to the culminating point of the recognition and comprehension of nature. . . . A more animating conviction, and one more consonant with the great destiny of our race, is, that the conquests already achieved constitute only a very inconsiderable portion of those to which free humanity will attain in future ages by the progress of mental activity and general cultivation. Every acquisition won by investigation is merely a step to the attainment of higher things in the eventful course of human affairs. . . .
>
> Forces whose silent operation in elementary nature, and in the delicate cells of organic tissues, still escape our senses, will, when recognized, employed, and awakened to higher activity, at some future time enter within the sphere of the endless chain of means which enable man to subject to his control separate domains of nature, and to approximate to a more animated recognition of the Universe as a Whole.[24]

Thus Humboldt concluded the second volume of his *Cosmos.* His life had radiated a most beautiful and generous quality of fostering and promoting the work of others, never viewing the accomplishments of someone else as a threat, but only another step in this larger enterprise. "Science is the labor of mind applied to nature," he wrote, and

> that which has been acquired by means so different—by the ingenious application of atomic suppositions, by the more general and intimate study of phenomena, and by the improved construction of new apparatus—is the common property of mankind.

Similarly, he had denounced the idea that other nations' prosperity would be a threat, rather than an asset, to one's own (an axiom of the British geopolitical school of Mackinder and Haushofer, which contributed enormously to the underlying British policies leading to World Wars I and II). "It were a pernicious prejudice, I would even say a godless one," he had once written, "to perceive the decline or ruin of old Europe in the increasing well being of any other region of our planet."[25]

The concluding words of the first volume of *Cosmos,* lead the reader from *that which is contemplated* to *that which contemplates:* from the domains of the inanimate and of the living, to the cognitive. Much as the final words of Bernhard Riemann's rehabilitation thesis of a few years later (which echoes Humboldt's phrasing), asserted the superior ontological character of unfolding physical processes to any formal mathematical representation of such processes, so Humboldt delivers the sum of all his work on nature and natural history, to the higher science of the human mind.

He began with a quote from his beloved brother Wilhelm:

> "If we would indicate an idea which throughout the whole course of history, has ever more and more widely extended its empire, or which, more than any other, testifies to the much-contested and still more decidedly misunderstood perfectibility of the whole human race, it is that of establishing our common humanity—of striving to remove the barriers which prejudice and limited views of every kind have erected among men, and to treat all mankind, without reference to religion, nation, or color, as one fraternity, one great community, fitted for the attainment of one object, the unrestrained development of the physical powers. This is the ultimate and highest aim of society, identical with the direction implanted by nature in the mind of man toward the indefinite extension of his existence. He regards the Earth in all its limits, and the heavens as far as the eye can scan their bright and starry depths, as

Stiftung Stadtmuseum Berlin, Graphische Sammlung, photo by Hans-Joachim Bartsch

Humboldt in his library, in the last years of his life. One of his legion of American visitors stated that he "went to Berlin, not to see its museums and galleries . . . its opera and theater; but to speak to the greatest living man in the world—Alexander von Humboldt."

inwardly his own, given to him as the objects of his contemplation, and as a field for the development of his energies. . . ."

Here Alexander continues:

With these words, which draw their charm from the depths of feeling, let a brother be permitted to close this general description of the natural phenomena of the universe. From the remotest nebulae and from the revolving double stars, we have descended to the minutest organisms of animal creation, whether manifested in the depths of ocean or on the surface of our globe, and to the delicate vegetable germs which clothe the naked declivity of the ice-crowned mountain summit; and here we have been able to arrange these phenomena according to partially known laws; but other laws of a more mysterious nature rule the higher spheres of the organic world, in which is comprised the human species in all its varied conformation, its creative intellectual power, and the languages to which it has given existence. A physical delineation of nature terminates at the point where the sphere of intellect begins, and a new world of mind is opened to our view.[26]

Timothy Rush, with a background in Ibero-American studies, has been active in the intelligence work and political organizing of the LaRouche movement for the past 28 years. His last feature-length contribution to 21st Century *was "Henry the Navigator and the Apollo Project," Summer 1992.*

Acknowledgements

The author wishes to give special thanks to Volkert Brenner, whose work in the German magazine *Fusion* provided a foundation for this study, and whose continuing collaboration is deeply appreciated. Thanks also go to Rick Sanders for assistance in translation.

Bibliography

In addition to the obvious place to begin in appraising Humboldt's life and work, which is with his own writings, it is fortunate for the English reader that three current biographies in English all have merit, and complement each other, rather than overlap: See Botting, De Terra, and Kellner. For those first delving into Humboldt, I particularly recommend Botting, because of the magnificent illustrations. The definitive biography, however, remains one in German, in two volumes, by Hanno Beck.

Hanno Beck, 1961. *Alexander von Humboldt* (Wiesbaden: Franz Steiner Verlag). Two volumes.

Douglas Botting, 1973. *Humboldt and the Cosmos.* (New York: Harper & Row).

Volkert Brenner, 1999. "200 Jahre Lateinamerikafahrt: Alexander von Humboldts Idee der Menschlichkeit: Das Universum 'geistig erobem'," *Fusion* Vol. 20, No. 3, p. 38.

Helmut De Terra, 1955. *Humboldt: The Life and Times of Alexander von Humboldt 1769-1859.* (New York: Alfred A. Knopf).

Alexander von Humboldt, 1845. *Cosmos, a Sketch of the Physical Description of the Universe.* Translated by E. C. Otté. (Baltimore: Johns Hopkins University Press, 1997 reprint). Two volumes.

Alexander von Humboldt, 1814-25. *Personal Narrative of a Journey to the Equinoctial Regions of the New Continent.* Translated and abridged by Jason Wilson. (London: Penguin Classics, 1995).

Alexander von Humboldt, 1811. *Political Essay on the Kingdom of New Spain.* Translated from French by John Black. (London: Longman, Hurst, Rees, Orm & Brown, reprint of 1900 edition, issued 1983).

L. Kellner, 1963. *Alexander von Humboldt.* (London and New York: Oxford University Press).

Peter Schoenwaldt, "Alexander von Humboldt und die Vereinigten Staaten von America," in *Alexander von Humboldt: Welt und Weltgaltung* anthology, Heinrich Pfeiffer, editor. (Munich: R. Piper & Co.).

Luis Vásquez, 1985. *El Mercantilismo Mexicano versus el Liberalismo Inglés (Mexico, D.F.: Editorial Benengeli).*

Notes

1. *Cosmos* I, p. 7. The many quotations from *Cosmos* in this article come, in the main, from the E.C. Otté translations of 1848-1865. This edition has been recently reissued in two paperback volumes by Johns Hopkins University Press. The inquiring reader will delight in the chance to delve into Humboldt's crowning work directly, without having to rely on snippets in secondary works. There are problems in the Otté translation, typically of the nature of dulling the liveliness of the original prose, and occasionally of content. For instance, in the very first paragraph of the introduction, Humboldt's cry of the heart, "Die Natur aber ist das Reich der Freiheit" ("Nature is above all the realm of freedom"), is rendered by Otté, "Nature is a free domain." But it was a contemporary, unexpurgated edition (see note 25 for British tampering with an earlier one), and will serve.
2. Brenner, p. 41.
3. Brenner, pp. 42-3.
4. See "The Franklin Circle Starts Modern England," by Anton Chaitkin, *Executive Intelligence Review,* Vol. 23, No. 7 (February 9, 1996), pp. 25-30, for the story of Franklin's work in fostering the industrial revolution in England—a revolution the British oligarchs tried to suppress.
5. Humboldt's close friendship with Goethe, which would continue without interruption until Goethe's death in 1832, is a study in itself. (See "The Natural Science of Wolfgang Goethe," by Ralf Schauerhammer, *21st Century,* Spring 2001, p. 12.) At several key points, especially in the 1797 period, it was contact with Humboldt that revived Goethe's interest in his natural science investigations. In 1816, Humboldt's final work on the geographic distribution of plants, dedicated to Goethe, arrived just when Goethe was grieving over the death of his wife. Goethe wrote to Alexander's brother, Wilhelm, "I owe to your brother, a sweet consolation, as his pamphlet reached me in one of the saddest moments. I like it so much that it came to be the daily text of my contemplations. Please forward the grateful note to him." (De Terra, p. 249).
6. This long and rich poem by Schiller, was written in 1795, in exactly the period when the contact between Schiller and Humboldt was at its height. It may be that Humboldt was privy to Schiller's creative process in writing the poem; it certainly summarized views that animated Humboldt for the rest of his life. It is notable, that in the section just before the line quoted so significantly by Humboldt, Schiller presents a string of powerful poetic images of expanding economic activity sustaining human life, and then extends this theme into the realm of the arts and sciences, in a way which must have entranced Humboldt: "There begets happy fortune the talents of heavenly children, / Nursed at freedom's fair breast, flourish the arts of delight. / Imitations of life by the sculptor give joy to the vision, / And the sensitive stone speaks, by the chisel besouled, / Heavens synthetic rest on slender Ionian columns, / And the Pantheon's walls all of Olympus contain. / Light as the the rainbow's vault through the air, as the cowherder's arrow, / bounces the bridge's yoke over the thundering stream. / But in the still of the room, outlining meaningful figures, / Brooding, the sage is in search, stalking the creative mind. / Matter's power he tests, the hatreds and loves of the magnet, / Follows the sound through the air, follows through aether the ray. / Seeks the familiar law in the awful wonders of hazard, / Seeks the immobile pole in the flight of appearances." (Translation by Marianna Wertz.)
   Humboldt's statement in the 1845 preface to *Cosmos,* that "In the late evening of an active life I offer to the German public a work, whose undefined image has floated before my mind for almost half a century," is a precisely dated reference to his years in Weimar with Schiller and Goethe.
7. Humboldt's published studies on the response of animal musculature to electrical stimuli, based on over 4,000 separate experiments in a one-year interval in the mid-1790s, converged on the design of a Voltaic battery, independent of Volta's own contemporary breakthrough in that field. He also published notable studies of the basalts of the Rhine Valley, and of plant growth underground in mines, without access to sunlight.
8. The material in this section is drawn from the superb book of Luis Vásquez, *El Mercantilismo Mexicano versus el Liberalismo Inglés,* and two groundbreaking unpublished manuscripts of 1982, "The Real Cultural History of Latin America: Charles III's Spanish Commonwealth," by Cynthia Rush; and "Contenido Político de la Expedición de Humboldt a America" by Sara Madueño de Vásquez. Their use is gratefully acknowledged by the author.
9. A partial inventory and description of these instruments is provided by Kellner, pp. 62-63.
10. One example from Humboldt's account: "We began to load the new pirogue. It was, like all Indian canoes, made from one tree trunk, hollowed out by axe and fire. It was 40 feet long and 3 feet wide. Three people could not squeeze together from one side to the other. . . . To make it wider at

the back of the boat we made branches into a kind of trellis, which stuck out on both sides. Unfortunately the leaf roof of this lattice-work was so low that you either had to lie down, and consequently saw nothing, or you had to stay hunched over. . . . The little cages with our birds and monkeys, increasing as we went on, were tied to the *toldo* and the prow. It was our travelling zoo. Despite losses due to accidents and sunstroke, we counted fourteen little animals when we came back from the Casiquiare. . . . In the overloaded pirogue, which was only three feet deep, there was no other room for the dried plants, trunks, sextant, compass and meteorological instruments but under the lattice of branches on which we were obliged to lie down for most of our trip. To take the smallest object from a trunk, or to use an instrument, we had to moor up and get ashore." (Humboldt, *Personal Narrative of a Journey to the Equinoctial Regions of the New Continent,* Penguin edition 1995, pp. 198-199.)

They lived on this pirogue in this manner for two months! Humboldt gamely observed, "With some gaiety of temper, with looking after each other and taking a lively interest in the majestic nature of these great river valleys, the travellers put up with the evils that became habitual," especially the "torment of mosquitoes that accumulate under the low roof, and the heat coming from the palm leaves continually exposed to the burning sun."

11. Kellner, p. 64.
12. An historian of the Arcueil circle writes, with unintended irony, that in those years, ". . . there was in the case of Laplace a more than common pliancy and understanding of political expediency," so that he could rise to Grand Officer of the Legion of Honor and Count of the Empire under Napoleon; and then Grand Cross of the Legion of Honor, and a marquis, in the following Restorationist regime of Louis XVIII. The same chronicler states that "The work of the Arcueil group was to represent almost a renaissance of Newtonianism. Much of this can be traced to the influence of Laplace. It is almost as though Laplace, hearing himself called the Newton of his age, accepted this title so literally and with such enthusiasm, that having successfully described the solar system, he turned to examine the numerous contributions to physics of the Great Man whose portrait hung in his study at Arcueil".
13. Arago, at age 20, had gone to Spain to help measure an arc of the terrestrial meridian, only to fall prisoner of the Spaniards when war broke out between France and Spain. Hiding the results of the survey on his body during two years in a Spanish prison and one year in an Algerian one, he finally returned to France in 1809 to duly hand over the results of the work. The first letter of congratulations to reach him was from Humboldt; this commenced a remarkable friendship which would last until Arago's death in 1853, at which time Humboldt personally wrote the preface to Arago's collected works, and saw them through to publication.
14. Brenner, p. 40.
15. Humboldt's emphasis on the role of landscape painting in developing popular enthusiasm for science, and his luminous descriptions of how only in the tropics, could one could find lush tropical vegetation directly adjacent to high mountain Arctic terrain (as in the equatorial Andes), inspired a group of mid-19th Century landscape painters, led by Frederic E. Church, to make pilgrimages to Ecuador and Peru, and paint from life, what Humboldt had painted in words. The resulting series of landscape masterpieces were the sensation of the New York salons on the eve of the Civil War. Church so revered Humboldt's vision, that he was preparing to send his huge "Heart of the Andes" painting directly to Humboldt in 1859, when word reached Church of Humboldt's death. (See catalog of the 1989 National Gallery of Art (Washington, D.C.) exhibit, *Frederic Edwin Church,* and the included essay by Stephen Jay Gould, "Church, Humboldt, and Darwin: The Tension and Harmony of Art and Science," p. 95.
16. *Cosmos* II, p. 117.
17. Brenner, p. 51.
18. De Terra, p. 269.
19. De Terra, p. 185.
20. De Terra, pp. 254-5.
21. Schoenwaldt, p. 432.
22. Bache told the 1859 Humboldt Tribute meeting in New York, that "It was to the letters of Arago that I owed the friendship of Humboldt. When the Coast Survey, of which I am superintendent, was attacked by one of. . . [the] strongest politicians of our day, Arago and Humboldt were the men to fly to the rescue of the work. They needed no preparation for this, and were ready at once with their letters expressing their sentiments as to the value of the work itself, and in regard to the way in which it had been executed; and it was to their testimony that the Secretary of the Treasury appealed, saying that the testimony of such men as Arago and Humboldt could not be set aside; and it was not set aside" (Schoenwaldt, p. 433).
23. Other visitors to Humboldt were the astronomer Maria Mitchell (whom Humboldt referred to in one of his letters as simply "Bache's friend"); Benjamin Silliman (close ally of Bache and key promoter of the Lincoln-era industrial breakout of the United States); George Ticknor (a graduate of Göttingen in the first group of Americans to pass through Gauss's home base in 1817, later to found the Boston Public Library); Charles Patrick Daly (later long-serving president of the American Geographical and Statistical Society); Dr. Joseph Green Cogswell (in 1823 founder of the first American school directly based on the German "Gymnasium" model developed by Wilhelm von Humboldt, and later commissioned by John Jacob Astor to scour Europe for the books to found the New York Public Library); Alexander Thayer, the biographer of Beethoven; and John Lloyd Stevens (founder of the first railway across the Panama Isthmus, and famous explorer of the Mayan ruins of Yucatán and Chiapas).

Bayard Taylor, translator of Goethe's *Faust* and later U.S. ambassador to Germany, expressed a veneration of Humboldt which appears as a leitmotiv in the diaries and letters of the Americans who visited Humboldt during these years: "I went to Berlin, not to see its museums and galleries, the beautiful avenues under the lindens, opera and theater; nor to enjoy the colorful life of its streets and salons, but to speak to the greatest living man in the world—Alexander von Humboldt" (Schoenwaldt, p. 445).

To the 1850 visit of Benjamin Silliman, we owe the following engaging account: In "a plain house in a quiet part of the city, [Humboldt] met us with great kindness in his library, a room of considerable size.... He has perfect command of English and speaks quite agreeably. There is no stateliness or reserve about him, he is as affable as if he had no claims to superiority. He conversed with an exceedingly musical voice, is animated and amiable, he stoops a little, has brilliant eyes, is of light complexion, his features and stature round but not fat, his hair thin and white, his conversation brilliant and sparkling with ideas. He was well acquainted with the *American Journal of Science,* with Col. Fremont, and Prof. Bache's coastal survey. He traced for us a canal project on a map, across the Isthmus at Darien.... He made some very interesting remarks about the present state of Europe, and on the impossibility of keeping down moral power by physical force." (De Terra, pp. 351-2).
24. *Cosmos* II, pp. 354-56
25. Humboldt had cordial relations with the handful of British scientists trying to revive any serious science in Britain, most notably Charles Babbage and John Herschel. One of Britain's leading Earth scientists, Edward Sabine, corresponded regularly with Humboldt, and later acknowledged that a crucial piece of his solution to the puzzle of the origin of magnetic storms (the sunspot cycle), came from a footnote in *Cosmos.* Sabine's wife, Elizabeth Juliana Sabine, was the first translator of *Cosmos* into English.

The British establishment, however, was deeply suspicious of, and at times openly hostile, to Humboldt, for the obvious reason that the thrust of his thinking and activity ran so directly counter to the British Empire's racism, and determination to keep its colonial areas backward. Humboldt's great desire, after the travels in the Andes, was to explore the other great "High Mountain" massif in the world, the Himalayas, and draw for Asia, the same enormous harvest of comparative measurements, which he had already done for South and Central America. To get there, he would have to gain permission from the British Government, and particularly from the British East India Company. Despite Humboldt's most determined personal intervention with British Prime Ministers Castlereagh and Canning, and a generous offer by Prussian King Friedrich Wilhelm III to cover the costs of the trip, the British door stayed firmly closed.

A reviewer for the British *Quarterly Review* in 1816, slammed Humboldt's investigations of the pre-Columbian civilizations of the Americas, with the following contemptuous words:

"We do not mean to deny that the first attempts, however rude, of an unenlightened people to register events, communicate ideas and render visible the operations of the mind, are void of interest; on the contrary, we consider them as so many landmarks by which we trace, in the most interesting manner, the progress of the intellectual faculties of man; but we wish to discountenance that perverse ingenuity which would mould and twist them to its own purposes and give them a meaning which they were never intended to bear.

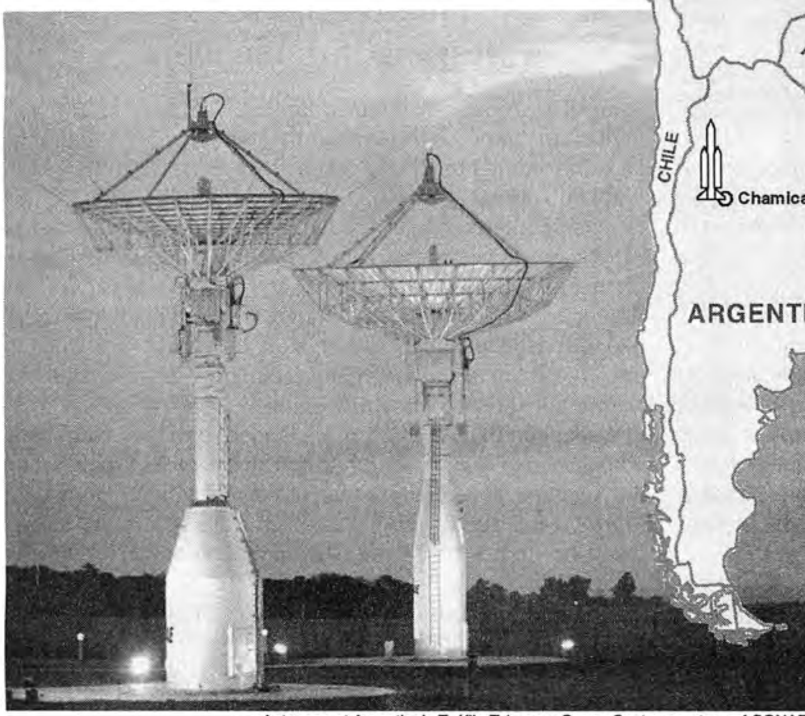
"Neither do we mean to deny that this people had their calendar and their chronology.... [S]till, we cannot admit with our author that a nation so barbarous as the Mexicans had any knowledge of the *causes* of eclipses or the Metonic period of nineteen years. A picture language or such rude representations of the objects of sense as village children chalk on walls and barn-doors, are the first and rudest efforts to record ideas, and the alescores of a village landlady the first approach to symbolic writing, and with both of these even the wild Hottentots called bushmen, the very lowest perhaps of the human race, appear to be acquainted.... The Mexicans may have advanced but, we believe, not a great way, beyond the village children, the landladies and the bushmen." (Kellner, pp. 99-100)

Even the circles friendly to Humboldt in Britain, eventually reflected some of the racialist dogmas gripping the British oligarchy. The Sabine translation of *Cosmos* eliminated key passages which disputed British assertions of where the origins of Man were to be located. John Herschel criticized Humboldt for failing to agree that the center of the land mass of the Northern Hemisphere was in a small town in midlands England, and urged that Humboldt rewrite a section of *Cosmos,* in order to portray Kepler's work as at a lower conceptual level than Newton's.
26. *Cosmos* I, pp. 358-359.

Ibero-America Needs A Space Agency!

by Marsha Freeman

It's time for all the nations of Ibero-America to put forward bold plans for space exploration, and for the developed nations to stop sabotaging such projects, under the guise of non-proliferation.



Antennas at Argentina's Teófilo Tabanera Space Center, courtesy of CONAE

The nations of Ibero-America together have all of the capabilities needed for a full-scope space exploration program. Argentina, Brazil, and Peru have facilities to launch scientific suborbital rockets, and Brazil is developing the Alcântara site, for satellites and, later, manned space flights.

For more than 15 years, Costa Rican-born astronaut Franklin Chang-Diaz has led a campaign to organize support for an Ibero-American space agency, similar in concept to the European Space Agency, which engages in large-scale projects through the participation of 15 nations. In October 2000, Dr. Conrado Varotto, the head of the Argentine Space Activities Commission, made a concrete proposal to create such a space agency for all the nations of Ibero-America, founded on joint activities between the region's two space powers, Brazil and Argentina, with "common specific and detailed objectives."[1]

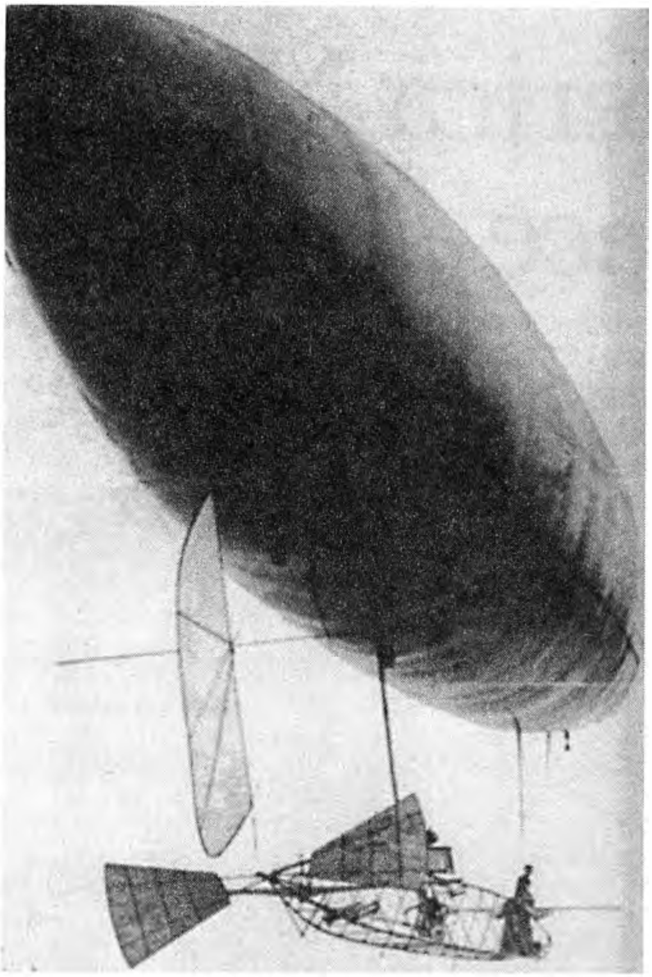


Photo by John Warick in *The International Encyclopedia of Aviation*, ed. David Mondey (New York: Crown Publishers, 1977), p. 326.

Brazilian Alberto Santos-Dumont, a daring balloonist and airship experimenter, is seen here in one of his powered aerostats. Inside the basket, which is suspended from the keel, is the inventor and pilot. An engine is driving a rudimentary propeller.

But is this really the right time for such a bold initiative?

Argentina is suffering a financial crisis which threatens its very existence. Laboring under the weight of tens of billions of dollars of unpayable and illegitimate debt, the economy has come to a near standstill. The import of life-saving medicines has stopped, international commerce is paralyzed, factories and farms are empty, and an increasing section of the population cannot even afford to buy food.

For Argentina to survive, it requires a financial reorganization that halts the debt payments, establishes a sovereign currency that is controlled and protected by the government, and directs new internal credit to restart agriculture, industrial production, and commerce. These are emergency measures, to be taken immediately.

In looking toward the future, Argentina, and all of the nations of Ibero-America, must not simply return to a better past, but take leaps into the future. From the time of independence in the 19th Century, until financial recolonization by the International Monetary Fund in the 1970s, the peoples of Ibero-America fully expected to develop their industry, science, and technology on a par with their developed neighbor to the north.

One barrier for Argentina, and all the developing nations of the world, has been the enforcement of so-called "nonproliferation treaties," especially by the United States, which has crippled developing sector nuclear and space programs by preventing the transfer of advanced technology. By preventing such economic development, the conditions of backwardness persist, laying the basis for civil unrest and war.

Can nations such as Argentina, suffering through such a grave crisis, afford to finance a space program? They cannot afford not to!

There is nothing more important to the long-term health of an economy than the development of the scientific and technical-industrial capabilities of a nation. Great infrastructure projects, like the exploration of space, mobilize these resources, upgrade education, inspire young people, and uplift a nation. By pooling their talents, capabilities, and resources, Ibero-America can move to the forefront of the exploration of the frontier of space.

And, contrary to common belief, Ibero-America is not made up of "Third World" countries starting space programs from scratch. These nations already have a long history of accomplishments in astronomy, aeronautics, and space, as well as in the applications of nuclear and other advanced technologies.

Ibero-America's Aeronautics Pioneers

In 1870, American scientist Benjamin Althorp Gould was invited to come to Argentina by then-President Domingo Faustino Sarmiento. Gould was a close associate of Benjamin Franklin's great grandson, Alexander Dallas Bache, the founder of the National Academy of Sciences and leader of American science in the 19th Century. Gould had studied in Germany with scientist Carl Gauss, had been part of the American System intellectual movement in Philadelphia, and had founded the Dudley Observatory in Albany, New York, in the 1850s. In Argentina, Gould founded and directed the astronomical observatory in Córdoba.

Walking in the footsteps of Alexander von Humboldt, along with a team of Argentine and American scientists, Gould set up the Argentine government's Meteorological Service. From 1872 to 1884, the Service built 52 observation stations to collect data, for studies of climate, hydrology, and the weather of Patagonia.

In 1885, one of Gould's associates at the observatory, Walter G. Davis, took charge of the Meteorological Service, which he directed for the next 30 years. In 1910, Davis's "Climate of the Argentine Republic" was published by the Department of Agriculture, and included the most comprehensive analysis of the climate, rivers, hydrology, magnetic characteristics, and weather of any part of South America. It was the handbook for the development of navigation, flood control, irrigation, and electrification, to be substantially improved only decades later, with the advent of space-based Earth remote-sensing technology.

But by the end of the 19th Century, a new frontier was opening, which promised to give man a new perspective on the world around him—travel through the atmosphere. In a number of countries in Ibero-America, excitement about this new venue for manned exploration was widespread, and propelled young enthusiasts to try their hand at the challenge of flight.

In Argentina, Jorge Alejandro Newbery (1875-1914), was an active member of the Argentine Aero Club, participating in a series of balloon flights. An explosion in 1908, in which his brother, Eduardo, perished, delivered a setback to the Aero Club. But Jorge Newbery, understanding the importance of developing this new technology, showed great courage and climbed aboard for two balloon flights the year after the accident.

In 1909, Newbery wrote an article for the daily newspaper *La Nación,* titled, "Aeronáutica." He states that the "amazement produced by the progress in aerostatics [ballooning] is not surprising." He described that technology as the "launching pad for a world revolution, linked not only to the science of war, but also representing a vast contribution to the study of meteorology, and a step toward resolving the ideal of the ease and rapidity of transportation."

Argentina was well suited to develop an aviation industry, Newbery states, which was the reason for the founding of the Aero Club. The balloon flights had a scientific purpose, "by taking practical and theoretical studies carried out in other countries into the field." By using the appropriate instruments, balloons could provide "scientific data from observations in the layers of the atmosphere, and other important matters, whose usefulness has been very appreciated by the wise director of the Meteorological Service, Walter Davis, who has spared no sacrifice to contribute to the greater success of the [balloon flights]."

Newbery's courage to resume balloon flights, and the enthusiasm generated through the article here cited, revitalized the Club. Spurred on by the Aero Club, in 1912, the field of Argentine military aviation was founded—the first in Ibero-America.

At the same time, "balloon fever" had also caught on in Brazil. Alberto Santos-Dumont was born in the Brazilian state of Minas Gerais in 1873. At the age of 18, he went to Paris, where, seven years later, in 1898, he took his first flight in a balloon. Santos-Dumont then began a project of developing his own lighter-than-air craft, powered by an internal combustion engine. He named his first small balloon, "Brazil." In July 1901, he circled the Eiffel Tower in his own dirigible, powered by a 15-horsepower engine driving a propeller, flying about 11.3 km. He won the 100,000-franc M. Deutsch de la Meurthe prize, and the "glamorous little Brazilian," as he was described, became internationally famous.

Santos-Dumont decided that heavier-than-air planes, rather than balloons, would be the future of flight. In 1906, his flying machine, with fuselage, biplane wings, an Antoinette motor, and a propeller, was ready for flight testing. His first attempts, on August 21, 1906, failed because of insufficient power. But on September 13, with a larger motor, he travelled 7 meters, or 33 feet. The next month, on his second flight, he travelled 60 meters in seven seconds, and in November 1906, flying about 5 meters above the ground, he covered a distance of 220 meters. This was the first successful powered flight by anyone other than the American Wright brothers.

Santos-Dumont also built small monoplanes, called Demoiselles, before he retired from his aeronautical researches, in 1910. He died in Brazil in 1932, and is considered the father of Brazilian aviation.

In Peru, engineer Carlos Tenaud Pomar, constructed a 36-foot monoplane, at the School of Arts and Trades in Lima in 1908. Tenaud had been educated at the Carnot Lyceum in France, and returned to Peru to work on the project. In 1910, the National Pro-Aviation League was founded in Peru, and soon afterwards, the Peruvian Air Club was established. Both were precursors of the Peruvian Air Force.

The establishment of the organizations promoting aeronautics in Peru were in large part the work of Pedro Paulet, himself a pioneer in aeronautics and space technology. (See "Pedro Paulet: Peruvian Space and Rocket Pioneer," by Sara Madueño Paulet de Vásquez, *21st Century,* Winter 2001-2002.) While others were still trying to design a ship that would fly in the atmosphere, Paulet was already designing craft that could fly beyond it, in space. During his studies in Paris from 1895 to 1898, Paulet reports, he carried out experiments with a liquid-fueled rocket engine, the first in the world.

Daring pilots from all over Ibero-America plowed new ground and set new records during the early years of aviation. In 1910, Peruvian pilot Georges Chavez made the first aerial

Von Braun: Why Argentina Should Be in Space

In December 1963, the Argentine magazine Revista Nacional Aeronáutica *published an interview with Wernher von Braun, who was then leading the effort in the United States to build the rockets that would take men to the Moon. Von Braun was asked what countries like Argentina could contribute to space research. He responded:*

> I am convinced that for countries like Argentina, a practical contribution to space navigation is not only feasible, but, even beyond that, equally desirable. Aeronautical technology is the advance guard which orients and defines technical progress in an infinite number of fields and disciplines, such as cybernetics (automation), electronics, measurement techniques, search for and knowledge of materials, etc. Therefore, all participation in programs linked to astronautics must echo advantageously, and have favorable repercussions in, the totality of industry's potential, affecting equally, and in a healthy fashion, the capacity for economic competition, without even considering—at least temporarily—the concrete fact that space exploration is the most fascinating undertaking facing our generation today.

crossing of the Alps, and in 1918, army pilot Lieutenant Canadalaria from Chile made the first flight across the Andes Mountains from west to east. Soon afterwards, German, French, and Italian companies were beginning regular commercial air service from Europe to Ibero-America, training local pilots and establishing aeronautics infrastructure.

This early interest in aviation in Ibero-America led to the creation of aeronautics research institutes, and later, industries to produce military and commercial aircraft. In the immediate post-World War II period, top European scientists, like German aerodynamics expert Kurt Tank, a former student of Albert Einstein, settled in Argentina. While at the Aerotechnic Institute, Tank designed the Argentine "Pulqui II" airplane, considered to be on a par with the Soviet MIG-15. By 1947, there were 392 foreign experts working at the Córdoba Aerotechnic Institute.

In Brazil, there had been partially successful attempts to establish assembly-line manufacture of aircraft, beginning in the late 1930s. In the 1950s, the government recognized that teams of highly qualified personnel were needed, as well as significant capital investment, which led to the establishment of the Center for Aeronautical Technology, (CTA), described as the "MIT of Brazil," and the Institute of Aeronautical Technology (ITA), under the Air Force. Aeronautical companies were also founded at that time.

In the 1960s, the Brazilian Air Force tasked the CTA to design, from scratch, a two-engine medium-sized transport plane to replace its aging fleet. The prototype Bandeirant (Explorer, or Pioneer) was completed in 1968, and the following year, Empresa Brasileira de Aeronáutica S.A. (Embraer), was founded as a state-owned company to begin production of the aircraft. It involved private industry in Brazil from the beginning, being 51 percent owned by the government, and 49 percent by shareholders. It was privatized at the end of 1994, and is now owned by a group of national investors.

In 1970, Embraer signed an agreement with the Italian manufacturer Aermachhi to manufacture the Xavante, a trainer and attack/photoreconnaissance aircraft. In 1972, the first EMB 110 was delivered to the Brazilian Air Force. Today, Embraer produces a full line of its own commercial passenger and military aircraft, including the EMB 145 AEW&C with a phased-array radar system, for early warning applications.

Embraer is the world's fourth-largest commercial aircraft manufacturer, and in the year 2000, it produced 160 planes, with a workforce of nearly 11,000 people. For the past three years, Brazil's leading export has not been coffee, but aircraft, at $2.3 billion last year. Embraer has subsidiary companies in Singapore, Australia, and China.

Prelude to Space Exploration

By the end of the 1920s, an explosion of interest in rocket technology development took place worldwide, emanating from the German Society for Space Travel, formed in 1927. The Society published magazines, debated opponents, and gave public presentations everywhere on rockets and flights to the Moon, from universities to the basements of department stores! In addition, a modest experimental program was carried out with the participation of the father of spaceflight, Hermann Oberth, and an enthusiastic young student, Wernher von Braun. Results were reported in their monthly magazine, and travelled around the world.

Sister amateur rocket and spaceflight societies sprang up, and during the 1920s and early 1930s, the German Society for Space Travel received inquiries about its activities from around the world, including Montevideo, Uruguay, and Buenos Aires, Argentina. The Argentine correspondent was Ezio Matarazzo, a first-year chemistry student at the University of Buenos Aires. In 1932, Matarazzo started the first astronautical magazine in Ibero-America, and formed a space travel group, Centro de Estudios Astronáuticos. Although it was short-lived, the organization published articles in *Aeronáutica Argentina.*

At the same time, another, more central Argentine figure, was starting an educational and organizing campaign for this new field of space exploration. As reported in a paper presented at the International Astronautical Federation Congress in 2000 by Dr. Oscar Fernández-Brital and Prof. Miguél Sánchez-Peña, Argentine Teófilo M. Tabanera began promoting space exploration in 1930.

That year, writing in the *Mendoza Illustrated News Magazine,* Tabanera stated: "The Moon is waiting for us. Before we imagine, the Moon will be reached. This world is too small for us; we must seek to expand outside." Using a comparison to be clearly understood by Argentines, Tabanera wrote: "Before making the first railway Mendoza-Buenos Aires, we made a short one from Buenos Aires to Palermo. Arriving at the Moon will give us the certainty of later reaching Mars and beyond." Tabanera volunteered to "accompany the

Embraer

Similar to the most advanced U.S. aerial early warning and control systems, the Embraer 145 AEW&C plane is equipped with an advanced phased-array radar, built in Europe by Ericsson. Brazil's main export is not coffee, it is aircraft.

first" crew on these missions, and said, "In my view, we need only a short time to solve all the details, choose the best method, and decide to begin the trip."

Throughout the rest of his life, Teófilo Tabanera dedicated significant effort to writing books about space travel, presenting papers and speeches on the importance of space applications (such as in education), and representing Argentina in international fora on space. In 1979, he wrote his last book, *Argentina Before the Challenge of the Third Millennium.*

In 1945, Tabanera became the first Argentine member of the British Interplanetary Society. Three years later, he founded the Argentine Interplanetary Society, which later became the Argentine Association of Space Sciences. For 10 years, it published the only monthly magazine on space subjects in Ibero-America.

Teófilo Tabanera brought space to Argentina, and brought Argentina into contact with the important people and international organizations promoting space exploration. In 1950, he attended the founding conference of the International Astronautical Federation (IAF), in Paris—the only delegate from a developing nation—and he attended each annual conference for the next 30 years. He hosted the 1969 IAF Congress in Mar del Plata, Argentina.

International Astronautical Federation

Argentine space pioneer Teófilo Tabanera (far right), pictured with colleagues at the 1952 Congress of the International Astronautical Federation in Stuttgart, Germany. With him are (from left) Dr. Irene Bredt, Prof. Hermann Oberth, Dr. Eugen Sänger, Dr. Fred Durant, and Dr. Arthur C. Clarke.

In 1952, Tabanera published a pocket book, *What is Astronautics?,* which was a bestseller and went through multiple editions. "Most of us became space addicts because of this book," the authors of the paper about Tabanera report. He led a public campaign to organize space studies in Argentina, and established the National Space Commission, serving as its first president.

At the 1969 Vienna meeting of the United Nations he lectured on tele-education, using satellite technology for all of Ibero-America, and in 1971, he proposed a very detailed study of how to best organize satellite television education for remote areas. Tabanera also attended every Apollo lunar launch, and the first, 1981, launch of the Space Shuttle, just months before his death.

When he died, the Argentine daily *La Nación* wrote: "The death of Ing. Teófilo Tabanera implies, for our country, the loss of a lucid observer and an intelligent visionary who attempted . . . to bring knowledge, to put his country on a basis of equity and justice within the world's scientific and technological community." Tabanera assumed that Argentina, and many of the nations of Ibero-America, would be an integral part of this greatest adventure of mankind.

Ibero-America on The Nuclear Frontier

The end of World War II brought onto the world scene the possibility of developing rockets for space exploration, and nuclear fission for energy. Nations in Ibero-America were anxious to exploit these revolutionary new tools.

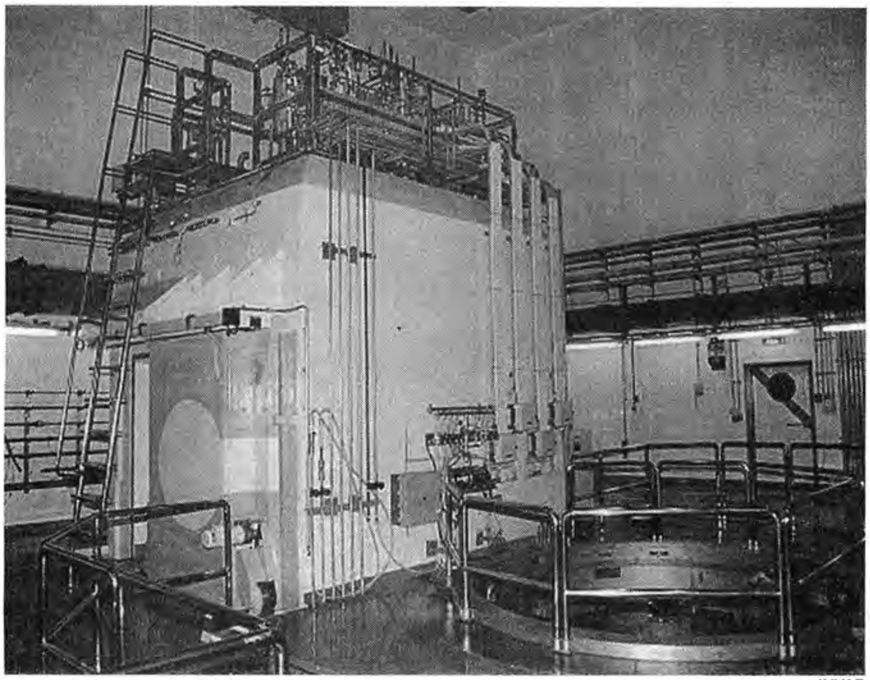
In Argentina, the postwar government of President Juan Perón invited several hundred European scientists to teach, and help develop that nation's scientific infrastructure. In 1950, the National Atomic Energy Commission was founded, to promote and control government and private research, and to draft proposals for the government for the use of nuclear energy. The decree creating the Commission noted "the Argentine Republic, unconcerned with any offensive intention, can work . . . with an elevated sense of peace, for the benefit of humanity."

The National Atomic Energy Directorate was founded the following year, to train the technical personnel to "direct, orient, and coordinate all of the studies relating to the use and application of atomic energy, as well as carry them out, if necessary." New research laboratories were created, and older, moribund scientific institutions were revitalized.

In 1953, with President Dwight Eisenhower's Atoms for Peace program, Argentina became the first nation to sign an agreement for cooperation in the peaceful uses of nuclear energy with the United States. At the first United Nations Conference on the Peaceful Uses of Atomic Energy in 1955, the delegation from Argentina presented ideas for more than 40 projects. Agreements for cooperation in nuclear technology were also signed by Argentina with several other Ibero-American nations, including Peru and Colombia.

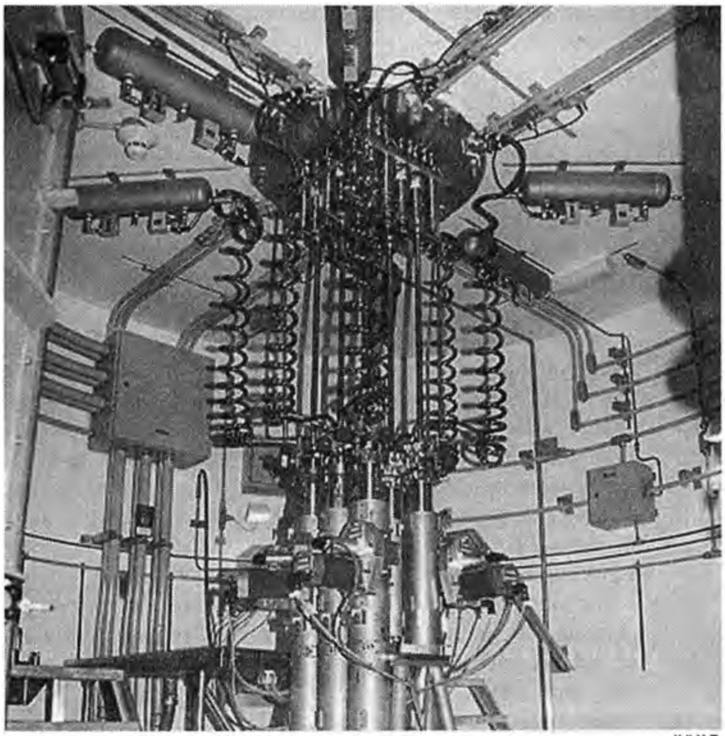
For the first decade of its nuclear program, Argentina concentrated on learning about the new science and technology of nuclear fission, carrying out educational and cooperative programs with various countries, especially Germany. In the 1960s, the first commercial nuclear power station was planned, to be sited in Atucha, about 100 km from Buenos Aires. It was built by the German company Siemens, and the 335-MW reactor came on line in 1974.

The second nuclear plant was sited near the scientific center



INVAP

Argentina's nuclear and space company, INVAP, built the ETRR-2 nuclear research in Egypt for studies in neutron physics and materials science, radioisotope production, boron neutron capture therapy for the treatment of cancer, and other research. INVAP also trained the engineers and technical personnel to operate the reactor. Seen here is the reactor hot cell.



INVAP

The Egyptian 22-MW thermal ETRR-2 reactor can accommodate up to 30 fuel elements. This view is of the control rod drives which are underneath the reactor pool.

of Córdoba. There was more participation from local industry in the construction of this Canadian CANDU reactor, as Argentina carried out a program of developing its own capabilities for designing and fabricating nuclear power plants. Construction of the second power plant, Embalse, began in 1974, and the plant became operational in 1983.

In 1977, the government promulgated a decree defining the national objectives of Argentina's nuclear program, which included achieving maximum autonomy. In 1979, a program was approved to build four new power plants, to come into operation between 1987 and 1997, along with the mining and use of domestic uranium. The first of this series was to be the Atucha II plant, for which a contract was signed with KWU of Germany. Unlike the construction of the previous two power plants, in 1980, an Argentine engineering company was established to take on the role of main contractor for design, and as architect-engineer. The plant was projected to be operational in 1988.

But Argentina's debt-induced "deteriorating economic situation" delayed construction, which paralyzed the nuclear program. Argentina also came up against a changed environment, in which anti-proliferation arguments were used to justify stopping the development of nuclear energy. In 1994, the government attempted to privatize Argentina's nuclear capacity, and seek private funding to complete Atucha II, but the effort failed to attract foreign capital. In 2001, the National Atomic Energy Commission completed a study which included the options for the unfinished Atucha II plant, which is 80 percent complete. It would cost $700 million to complete the project, they estimated, and more than $3 billion to abandon it.

In May 2001, speaking at the 10th annual Ibero-American Energy Conference in California (which state was in the midst of its own deregulation-caused energy crisis), Argentina Energy Secretary Alejandro Sruoga said that the government planned to push ahead with the foolhardy sale of the country's two nuclear units, and its plan to deregulate the country's electricity sector.

Argentina's ongoing financial collapse and economic crisis have put all of these plans on hold. In February this year, the president of the National Atomic Energy Commission resigned, in the political upheavals that accompanied the bankruptcy of that nation.

But while it was importing commercial nuclear power plants, Argentina fully planned to become a world supplier of nuclear energy technology, and a competitor to the otherwise "developed" nations. The Province of Río Negro established the company, INVAP, in Bariloche in 1976 to develop, build, and internationally market indigenous Argentine nuclear technology. INVAP is also the only company in Argentina that meets NASA qualifications for complete space projects, such as the construction of satellites, payloads, and ground stations.

In 1982, INVAP inaugurated the first reactor designed and built in Argentina. This was the 500 kilowatt RA-6 research and training reactor, located at the Nuclear Center Bariloche, run by the National Atomic Energy Commission. It is operated, maintained, and repaired by local personnel, who include nuclear engineering students at the Balseiro Institute of Physics and Nuclear Energineering, named for the founded of the Atomic Energy Commission, José Antonio Balseiro.

Argentina also started exporting nuclear technology. The first small research reactor it built was for Peru.

In 1985, INVAP signed a contract for the construction of a 1-MW thermal Multipurpose Reactor for research, in Algiers. It was inaugurated in 1989, and is similar in general design to the RA-6. The reactor is used for laboratory-scale production of radioisotopes for basic and applied research, and for the training of operating personnel. To ensure the transfer of technology, more than 50 Algerian engineers and technicians participated in the project from the time of the contract signing.

In 1992, INVAP won an international bid tendered by the Atomic Energy Authority of Egypt, and a contract was signed to provide a reactor for research activities in a broad range of nuclear-related science and technology applications. Formal commissioning of the reactor, at Inshas, 60 km from Cairo, began in 1997, and the reactor reached its rated power of 22 MW thermal the next year. In February 1998, Presidents Hosni Mubarak of Egypt and Carlos Menem of Argentina inaugurated the reactor. Many of the reactor's key components—60 percent of the project—were manufactured by Egyptian companies.

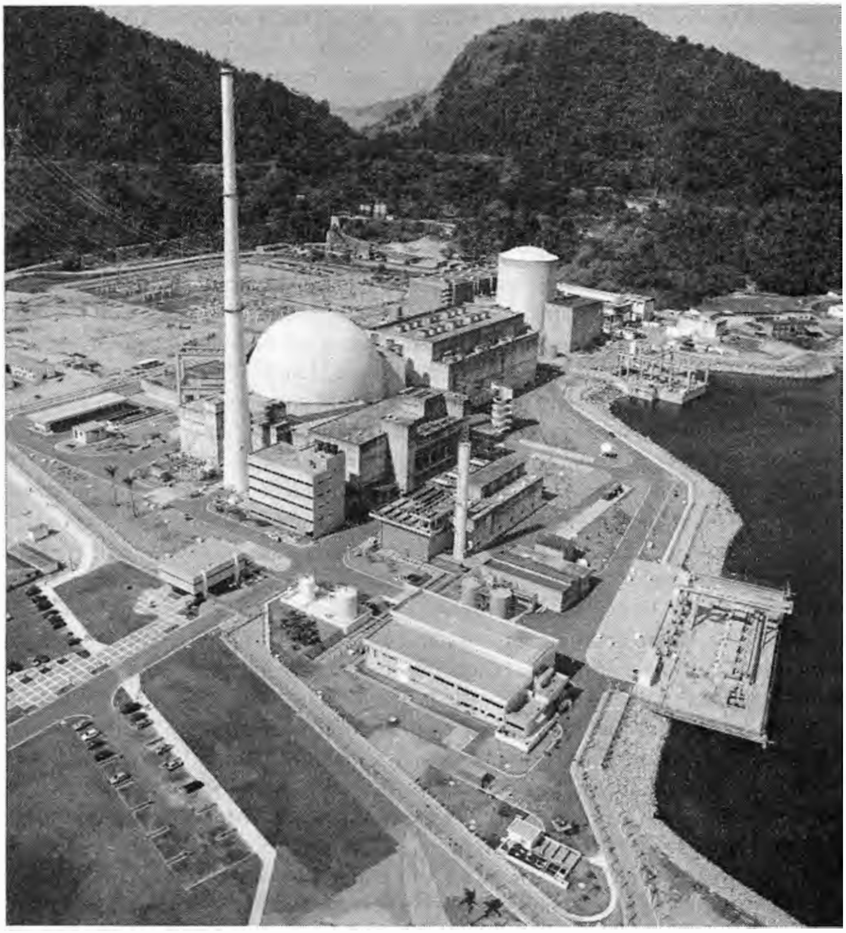
The Australian Nuclear Science and Technology Organization (ANSTO) announced in July 2000, that it had selected the Argentine company INVAP to build a 20-MW reactor to replace its existing research reactor. ANSTO stated that Australia's replacement reactor would be only one of two in the world to use some of the latest technology optimized for scientific investigations, and that the performance would be "comparable to the national neutron sources of Japan, France, and the USA." ANSTO reports that the contract, worth $278.5 million, "represents the largest single investment in science and technology in Australia's history, and is among the largest infrastructure developments of its kind in the Asia-Pacific region."

In the mid-1980s, Argentina began the CAREM Project to design small (under 300 MW), modular commercial nuclear power plants, and produce them for export to developing countries. The goal included the training and education of specialists in these nations, to spread nuclear science and technology worldwide. While the world economic crisis has suppressed the demand that should exist for such small, standardized nuclear plants, Argentina's CAREM design is one of the front-runners for exporting plants to developing nations.

The Case of Brazil

A parallel process of nuclear science and technology development has taken place in Brazil. As early as the 1930s, scientists at the University of São Paulo were conducting research in nuclear fission. In 1940, President Getulio Vargas signed an agreement with the United States, for the cooperative mining of uranium, in return for nuclear technology, and a committee was created to examine nuclear ties with the United States. At the same time, Brazil made the decision to work to develop an independent nuclear capability.

In 1955, an agreement was signed under Atoms for Peace, for the transfer of nuclear technology from the U.S. to Brazil, with Brazil's expectation that this new technology would lay the basis for the postwar industrial development, and eco-



The successful completion of the second unit at the Angra nuclear complex (foreground), although delayed, is a testament to the commitment of the Brazilian government to exploit the advantages of nuclear energy for economic development, in spite of the decades-long U.S.-led policy of "denial" of nuclear technology.

nomic independence, of Ibero-America.

The next year, in 1956, the Institute for Energy and Nuclear Research was created, followed by the Brazilian National Commission for Nuclear Energy (CNEN). In 1957, under the Atoms for Peace Program, Brazil built the first of two nuclear research reactors, with U.S. support. A second reactor was developed in 1960, and in 1965, Brazil built its first indigenous research reactor, in Rio de Janeiro.

Throughout the 1960s, CNEN performed feasibility studies for the siting of Brazil's first commercial nuclear power plant, and the site chosen in 1968 was at Angra dos Reis, 130 km from Rio. The 625-MW Angra I power plant, built by Westinghouse, began construction in 1972, and went into operation in 1982, providing 20 percent of the electricity for Rio de Janeiro. But the Westinghouse contract barred the transfer of nuclear technology to Brazil, so other suppliers were sought.

After the 1973-1974 oil crisis, and attendant quadrupling of oil prices, Brazil's President, Ernesto Geisel, created the Brazilian Nuclear Corporation (Empresas Nucleares Brasileiras S.A., or Nuclebras), which consisted of companies for engineering, construction of reactors, and fuel cycle activities. Its job was to expand the country's nuclear power programs.

Stan Ezrol/EIRNS

Henry Kissinger, seen here in 1983 at the State Department, was (and still is) a prime mover in promoting arms control agreements, and "nonproliferation" policies, as a tool for withholding advanced nuclear and space technologies from developing nations.

In 1975, over strong objections from the United States, Brazil signed a cooperative agreement with Kraftwerk Union AG in Germany to build up to eight additional nuclear plants, including Angra II and III, a commercial uranium enrichment facility, and a pilot-scale plutonium reprocessing plant, to close the nuclear fuel cycle. West Germany did not require safeguards under the International Atomic Energy Agency of the United Nations. Soon after the start of construction, a financial crisis in 1982 in Brazil led it to negotiate loans with the International Monetary Fund. That institution demanded that, as a "conditionality" for a loan, Brazil limit the nuclear pact with Germany. The number of planned power plants was reduced, to include only Angra II and III; the two other plants were cancelled.

In 1991, the decision was made to resume construction, and by 1996, the resources were so allocated. In July 2000, Angra II, double the capacity of the first plant, was finally connected to the electric grid. More than 50 percent of the power plant's equipment was made by Brazilian firms.

Concerning Angra III, for 15 years, the partially completed power plant has been mothballed, with complaints that nuclear power is "too expensive," that the electricity is unnecessary, and that it is even "unsafe." The government has been unwilling to finance its completion, although almost $2 billion has already been spent. About 70 percent of the needed hardware from Germany has been shipped, and is in storage. The plant is about 30 percent complete, and $1.7 billion is needed to finish Angra III. But recently, out of necessity, the government began reconsidering the completion of Brazil's third nuclear power plant.

In May 2001, Brazil's President Fernando Henrique Cardoso announced that a multi-year drought had brought reservoir reserves to 30 percent of normal, and that electricity from the nation's hydroelectric plants would have to be rationed. Three quarters of the nation's 170 million citizens were told to reduce consumption by 20 percent. As a result of the crisis, later in the summer, the National Council for Energy Policy asked for a "detailed analysis" in order to reconsider the completion of Angra III. That study is to be completed by the end of this year.

Unfortunately, outside private investment is being sought to complete the plant, and Electronuclear, the state-owned company that runs Angra I and II, is trying to arrange financial support from abroad. It is hoped that the bankruptcy of Brazil's neighbor, Argentina, and the financial reorganization and debt cancellation that is necessary there, will create the conditions in Brazil for a return to a policy of national self-interest, and national investment in power and other infrastructure.

The Non-Proliferation Hoax

But it was not just a series of financial crises in Ibero-America that has stunted nuclear energy programs. The attempt to put international controls on nuclear technology began virtually before the end of World War II. And in 1977, with the accession of Jimmy Carter to the White House, negative-growth Malthusian ideology, centered on "nonproliferation" policies to stop economic development, were fiercely directed against nuclear power, both in the United States and internationally.

In order to continue to have access to commercial nuclear power technology, nations were pressured to sign the Nuclear Nonproliferation Treaty (NPT). The Treaty was signed by the Soviet Union and United States on July 1, 1968, and it was ratified by the U.S. Senate two years later. Although the Treaty includes the language that "nothing in this Treaty shall be interpreted as affecting the inalienable right of all the Parties to the Treaty to develop research, production, and use of nuclear energy for peaceful purposes without discrimination," virtually no non-nuclear country believed it would ever gain unfettered access to peaceful nuclear technology under this regime.

Later, under pressure from the Carter Administration, the U.S. Congress passed the 1978 Nuclear Non-Proliferation Act, which amended the 1950s Atomic Energy Act, and unilaterally suspended nuclear exports to countries that refused to sign the Treaty. These measures were even applied *retroactively* to suspend shipments of nuclear fuel to Brazil for its operating Westinghouse Angra I reactor.

The Carter Administration threatened reprisals if Brazil and West Germany did not accept conditions in their 1975 bilateral nuclear contract, agreeing to subject any spent fuel reprocessing to international control, and to allow U.S. involvement in controlling nuclear technology transfer between them. The idea of controlling so-called "dual use" technologies, such as spent fuel reprocessing and breeder reactor technology, became policy. Under the guise of preventing countries that did not already have a nuclear bomb, from developing one, the policy sought to prevent nations from becoming self-sufficient in civilian nuclear energy. Both Argentina and Brazil rightly considered such restrictions a violation of national sovereignty.

The unrelenting campaign to force Argentina and Brazil to sign the NPT rested on the assumption that because the research and development programs were led by, or at least involved with the armed forces, these were, without question, military projects, aimed at developing "weapons of mass destruction." This completely ignores what the *intention* was of these two nations, in developing nuclear technology. Even after Brazil and Argentina—the only two Ibero-American nations that could possibly resort to the use of nuclear weapons in a war with each other—had signed bilateral agreements in the 1980s to *share* their nuclear technology, one-world nonproliferators insisted that these programs were still "suspicious."

Stuart Lewis/EIRNS

During President Jimmy Carter's Administration, from 1977 to 1980, the Council on Foreign Relations' policy of "controlled disintegration" of the U.S. economy, based on deregulation, was accompanied by a campaign to stop the ambitious nuclear development projects then under way in United States and overseas, under the rubric of "nonproliferation."

In fact, in the United States, it was the leadership of the U.S. military that created the first scientific institutions and basic infrastructure upon which the economic development of this country has depended. The earliest advanced education available, especially in science, mathematics, and engineering, was through military academies, such as West Point. The Army Corps of Engineering built the physical infrastructure prerequisite for westward development. The military institutions in Ibero-America, likewise, have played a major role in creating, organizing, and focussing the scientific talent of the nation. They understand that the first line of defense of any nation is its scientific and economic strength.

If there were ever a legitimate concern that these two nations would develop nuclear weapons, making nuclear technology unavailable from the established nuclear powers only strengthened the resolve of both to develop their own indigenous nuclear industries. Thus, the policy of denial only defeated the supposed purpose of the Treaty.

In reality, former Secretary of State Henry Kissinger had clearly laid out the real purpose of such "nonproliferation" policies in 1974, when National Security Study Memorandum 200 warned that population growth in the Southern Hemisphere's developing nations, would threaten the national security of the United States, by using up allegedly finite resources.[2] Kissinger had also publicly stated his belief that no advances for mankind would ever come from the "South." Such a geopolitical agenda, which in later decades became known as "technological apartheid," were the underlying fundamentals of President Carter's anti-nuclear, anti-growth policies.

Today, the very existence of even the hobbled nuclear energy programs in Brazil and Argentina stand as examples of what can be achieved, with the commitment to attain scientific, technological, and economic parity with the nations that are considered "advanced," or "developed."

The same long-term perspective and commitment of resources was required for these nations to enter the space age.

Studying the Earth From the Equator To Antarctica

As soon as the space age began, only a few years after the start of the nuclear age, nations in Ibero-America were anxious to participate. The launch of the Explorer I satellite in January 1958 demonstrated, through the discovery of the Van Allen radiation belts, that rockets could open up a new era of exploration of the Earth's near-space environment. And the location of Brazil and Argentina alone, with access to the geophysical singularities at the equator and Antarctica would place Ibero-America in a key geographic position for scientific studies.

In 1961, Brazilian President Jânio Quadros signed a decree creating the organizing group for the National Commission of Space Activities (CNEA), under the National Research Council. It was directed by Col. Aldo Vieira da Rosa. The Commission developed a program to create technical laboratories in São José dos Campos, related to development of the technologies for studies in space and atmospheric sciences.

One important target for study was the region of Barrèira do Inferno in Rio Grande do Norte. It is positioned within just 5 degrees of the Earth's magnetic equator, (which is inclined 11 degrees from the equator), where a magnet would align itself with the surface of the Earth. It is an important region from which to study phenomena in the Earth's ionosphere, which extends between 60 and 500 kilometers from the surface. This atmospheric layer contains free electrons and ions, and its degree of ionization changes depending on time of day, season, solar activity, and so on.

In 1965, the government of Brazil began construction of a launch site at Barrèiro do Inferno, in order to launch rockets to study the lower altitude layers of the Earth's ionosphere, and a cooperative agreement was signed with NASA to study the ionosphere at altitudes below 200 kilometers. NASA supplied the suborbital sounding rockets for carrying aloft the scientific

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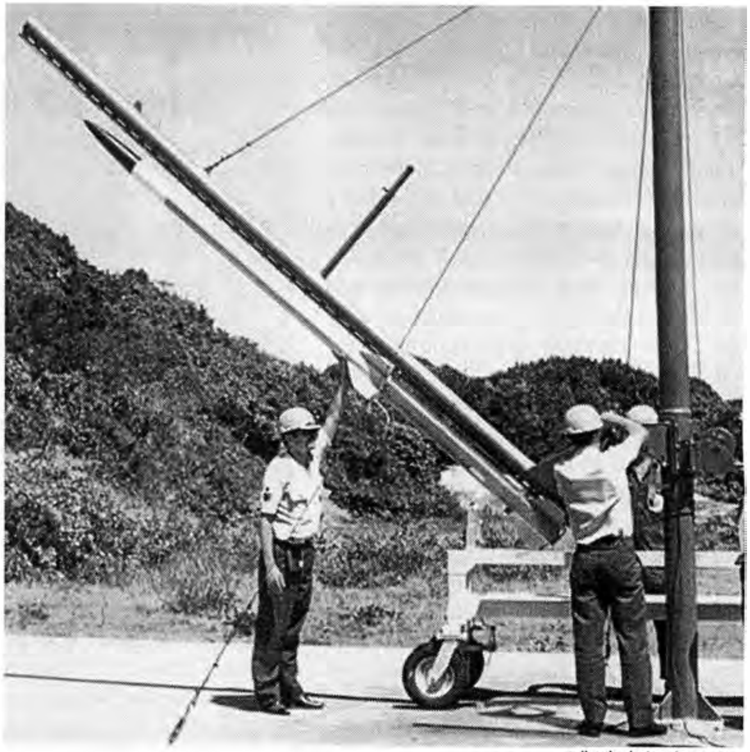
The Orion rocket, shown here, was one of a series of suborbital sounding rockets developed by the Argentine Air Force, to carry scientific experiments from launch sites at Argentine bases in Antarctica.



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A Brazilian Sonda sounding rocket is readied for launch. The scientific instruments on board provide data on the characteristics of the electrically conducting ionosphere, above the magnetic equator. Sonda rockets are used as stages in Brazil's larger VLS rocket, which is designed to launch satellites into orbit.

instruments. The first launch in the series from Barrèira do Inferno was on December 16, 1966, and experiments continued from this site through the 1980s.

At the same time, Brazil began the development of its own sounding rockets with the Sonda Program. The objective was to develop a series of launch vehicles incorporating incremental improvements through indigenous technology development, culminating in a rocket powerful enough to place satellites into Earth orbit.

Sonda I, first launched in 1965, was a two-stage solid-fueled sounding rocket, weighing only 5 kilograms, and capable of reaching a 70-km altitude, while carrying a payload of scientific instruments. Sonda II, developed to test improved propellants, aerodynamics, electronics, and thermal protection, was a single-stage rocket, 30 of which were launched. It was able to reach an altitude of 180 km with a 50-kg scientific payload.

Sonda III, which first flew in 1976, was a two-stage rocket, using the improved Sonda II as one of its stages. It was used as a meteorological rocket that reached up to 600 km with a payload of up to 500 kg.

In 1984, Sonda IV was launched, designed to loft 300 kg of payload to 1,000 km, and was the precursor for the VLS (Veículo Lançador de Satélites) rocket series, capable of delivering satellites to Earth orbit.

Argentina at the Pole

While the equatorial region was under study by Brazil, scientists were taking advantage of Argentina's long history of exploration in Antarctica, to carry out rocket launches for atmospheric study.

In 1960, the National Commission on Space Research (CNIE), was established by Presidential Decree, under the Air Force. Three years later, the Air Force Institute of Aeronautics and Space Investigations (IIAE) was planning experiments at extreme southern latitudes, near the South Pole. Argentina had established the first Antarctic observatory, "Islas Orcadas," in 1904.

In a 1999 paper titled, "Scientific Experiences Using Argentinean Sounding Rockets in Antarctica," Prof. Miguél Sánchez-Peña, a retired Air Force General who participated in the Antarctic science campaigns, described the technology developed, and research carried out, near the southernmost reaches of the globe.

The IIAE worked on the design of sounding rockets for atmospheric study. The first scientific campaign was conducted on the volcanic island of Larsen, at the Matienzo site, which had been founded in 1961. In 1965, the Air Force team arrived by airplane and on an icebreaker, along with the rockets. Three Centauro rockets and two polyethylene balloons were launched to take measurements in the atmosphere.

Three Gamma rockets were launched simultaneously from the range at Chamical Centro de Experimentacion y Lanzamiento de Proyectiles Autopropulsados, in the Providence of La Rioja, 3,900 km from Matienzo, in order to compare the data.

The Chamical range was also used into the 1980s for sounding rocket studies of the atmosphere in the Southern Hemisphere. The Inter-American Experimental Meteorological Rocket Network, EXAMATNET program, involved scientific institutions in Argentina and Brazil, and NASA. And the Marambio base in Antarctica was used for atmospheric ozone studies from 1980 to 1982.

At the Marambio base in Antarctica, which was inaugurated in 1969, two-stage Argentine Castor rockets were launched in 1975, with a scientific payload developed by the Max Planck Institute in Germany. A shape charge with a special chemical mixture was ejected into the atmosphere to form an ionized cloud. The cloud produced a jet of electrons reaching to the conjugate point in the Northern hemisphere, and was observed by ground-based observatories in Argentina and by NASA aircraft flying east of New York. The objective was to study the electrical and magnetic fields at different altitudes, find neutral points, and compile temperature and electron profiles.

Like Brazil, Argentina created the educational institutions and research and develoment infrastructure to establish its own space launch capability. In 1958, the Fábrica Militar de Aviones began to develop solid propellant rockets, and manufactured families of launch vehicles, including the Centauro family, with alpha, beta, and gamma versions, and the Orion, Canopus, and two-stage Rigel and Castor rockets.

By 1979, the IIEA, on the outskirts of Córdoba, had research facilities covering the full range of technologies needed for launch vehicle development, including those to develop new propellants and solid fuels, to do aerodynamic research using wind tunnels, perform structural tests on space hardware, and develop computing, guidance and control, metallurgy, and materials capabilities.

While the nations of Ibero-America were training their cadres of scientists and engineers, and beginning the development of national space programs, they were ready to take advantage of the practical applications of space technology that rockets and satellites were already making available.

Using Space for Earth Applications

Brazil, which has a land area larger than that of the United States, extends from 3 degrees north to 34 degrees south of the equator. From the start of the space age, it was clear that Brazil would be one of the countries that would benefit greatly from being able to study and monitor its coastline, land area, and environment from space. In 1966, the first Brazilian ground station to receive meteorological images from satellites was installed.

In 1971, President Emilio Garrastoyu Medici created the Brazilian Commission for Space Activities to advise him in planning national space priorities. The same year, a world-class remote-sensing capability began its development, with the establishment of the Instituto Nacional de Pesquisas Espacais, or National Institute for Space Research, INPE.

In 1973, Brazil became the third country in the world (after the United States and Canada), with a ground station, to directly receive remote-sensing images from NASA's Landsat satellites. Brazilians came to the United States to be trained to interpret and process Landsat data, and through its laboratory facilities in São José dos Campos, INPE did remote-sensing image data processing for Uruguay, Chile, Peru, and Colombia.

Since 1971, INPE has offered a masters degree program in space science, which was expanded to include a doctoral program in 1997. Early on, 50 promising students per year were sent to the United States and Europe to become acquainted with the most advanced remote sensing technologies. At the same time, American experts went to Brazil to help formulate space policy.

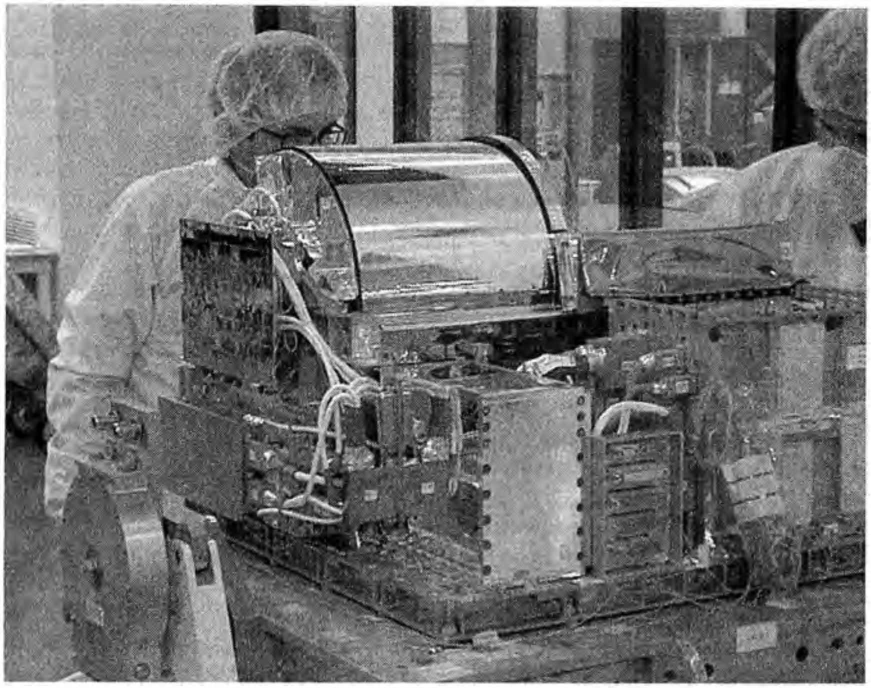
Very quickly, Brazil's leaders realized that an overall, long-term policy was needed to direct investment in space technology, and in 1980, the Complete Brazilian Space Mission was approved. The three goals of the program were to develop, (a) indigenous satellites, (b) a launch vehicle, the VLS, to put the satellites into low-Earth orbit, and, (c) a launch center at Alcântara. The $1 billion program had the aim of attaining self-sufficiency in space technology, similar to the goal in nuclear energy, and was estimated to require a team of 1,000 Brazilian scientists and engineers.

New facilities were added at INPE, including a Center for Weather Forecast and Climate Studies, which produces five-day weather predictions, and is the only center of its type in the Southern Hemisphere. The Integration and Test Laboratory is also a unique facility, where small indigenous satellites can be assembled and tested, and large foreign commercial communications satellites can also be accommodated for testing.

The Complete Space Mission specifically authorized the development of four Brazilian satellites. One pair was the Satélite de Coleta de Dados, or SCD, the first of which was placed into orbit by an American Pegasus rocket in 1993. It was Brazil's first homemade satellite, and cost $14 million. The second SCD satellite was launched in 1998. The purpose of the SCD satellites is to function as relays for data collected from platforms like ocean buoys and atmospheric measurement instruments. Data from more than 250 automated collecting platforms in Brazil and neighboring countries comprise this network, with the largest number installed by the National Agency for Electrical Energy. These data are used to monitor eight hydrographic basins, allowing the management of water resources, forecasts, and flood alerts.

The data collected are transmitted to satellites, and then are relayed to receiving stations on the ground, which process the information. The information is delivered to the user in less than 30 minutes from the time the satellite passes overhead, and is also available on the Internet.

The second pair of satellites, SSR 1 and 2, will provide complete remote-sensing coverage of Brazil every four days, supplying data needed for monitoring natural resources, like forest clearance and burning in the Amazon, and disasters, such as flooding in the south of Brazil. Landsat can provide such images only every 16 days, and the European SPOT satellite,



NASA/ Goddard Space Flight Center

Brazil is using its decades of experience in Earth remote-sensing technology to provide the Humidity Sounder for Brazil instrument that will fly on NASA's Aqua satellite. Aqua will be launched this spring.

every 26 days.

The cost of the constellation of four remote-sensing satellites is $280 million, about 80 percent of which is being spent in Brazil.

Because the Amazon covers 5 million square kilometers of land area, larger than Western Europe, it can only be observed by air or space. Brazil is involved in a multi-faceted project of monitoring the Amazon, for a variety of purposes, including illegal narcotics activities. In 1974, Brazil started to monitor the deforestation of the Amazon, using images from Landsat. It is now engaged in the PRODES project, for Estimate of Amazon Gross Deforestation, which began in 1988. PRODES is the largest forest monitoring project in the world, and is part of the $1.4 billion Amazon Protection/Amazon Surveillance System, under development by INPE. One proposal for international cooperation has been to extend PRODES to cover the tropical forests in the broader Panamazonia, which would cost only 10 percent of each nation doing the observing individually. Amazonia itself covers parts of Guyana, Surinam, French Guyana, Colombia, Ecuador, Peru, and Bolivia, in addition to Brazil.

At the same time that Brazil was making progress in designing, building, and testing its own satellites for remote sensing, it was also developing a series of small satellites to test space technologies for various applications. The SACI-1 satellite, weighing only 132 pounds, was launched in October 1999. The $4.6 million spacecraft was designed to test antenna, battery, power, and computer systems technologies in space. Unfortunately, INPE was not able to make contact with the satellite after launch.

SACI-2 was a meteorological satellite, launched two months later, on the Brazilian VLS rocket. But the second stage of the launcher failed and the satellite had to be destroyed. These efforts, however, demonstrated that Brazil was fully capable of building its own satellites, a capability crucial for the future space development in all of Ibero-America.

Brazil has continued to play a leading role in developing technology for satellite remote sensing. It is contributing the Humidity Sounder for Brazil Experiment, to fly on NASA's Aqua Earth observation satellite. This is a passive microwave radiometer, designed to provide profiles of atmopsheric humidity, and detect precipitation underneath clouds. In the tropics, vertical humidity variations are more of an influence on cloud formation and precipitation than that of temperature. Matra Marconi Space is developing the instrument, under contract with INPE.

Aqua is a multi-disciplinary study of the interrelated processes of the atmosphere, oceans, and land surface. Other instruments on board will provide information on sea-ice concentration and temperature, snow cover, and soil moisture. The launch is planned for spring 2000.

Argentina in Space

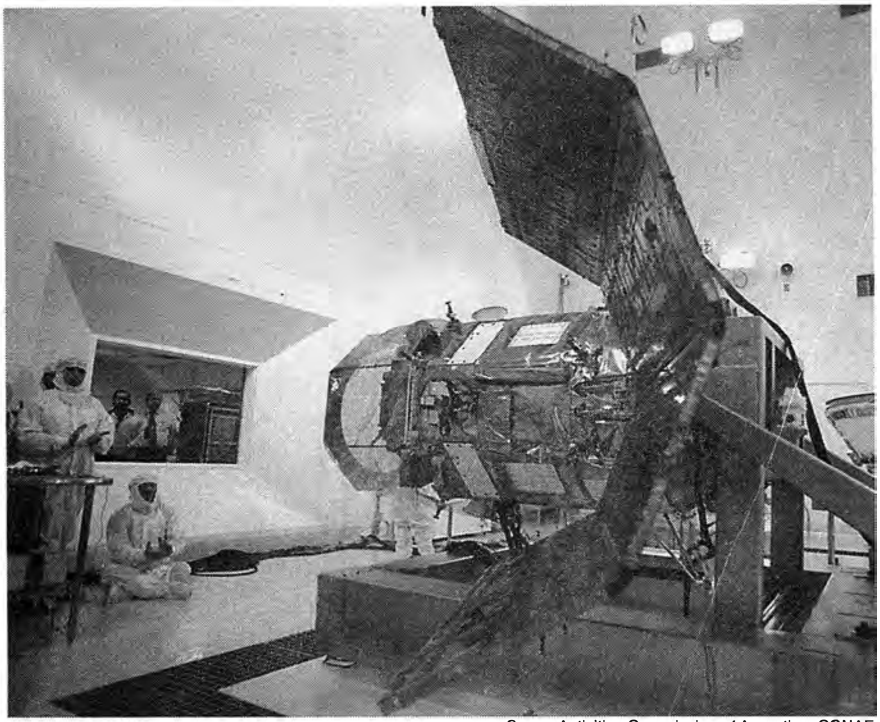
Like Brazil, Argentina recognized that the first application of space technology of economic importance would be the ability to see the Earth from space. In the 1970s, the National Commission on Space Research outfitted the Vicenta Lopez Space Center with technology to do processing of Landsat data.

But unlike Brazil, which decided in 1980 to formulate and implement a wide-ranging, long-range plan for space development, Argentina did not do so for another decade. Even so, in 1989, the Presidents of both nations signed the Joint Brazilian Argentinian Declaration on Bilateral Cooperation on the Peaceful Uses of Outer Space, and two years later, the Argentine government established CONAE, the Argentina Space Activities Commission. In 1994, CONAE promulgated the National Space Program, "Argentina in Space 1995-2006." It is to be reviewed every two years, and have a permanent horizon of one decade.

The first Argentine-built satellite was designed even before this 10-year program. It was the first in the series of SAC (Satélite de Aplicaciones Científicos) satellites, built by INVAP, which also produces Argentina's small nuclear reactors. In 1990, Argentina petitioned NASA for joint space work. In November of that year, President Bush and his science advisor, Dr. Alan Bromley, visited Argentina, and an agreement was made to develop a solar X-ray satellite with NASA's Goddard Space Flight Center. In August 1991, Vice President Quayle and President Carlos Menem signed a framework agreement for cooperation with NASA on Earth and space science, and the SAC-B mission was formalized. This was the first joint spacecraft mission by NASA with a country in Ibero-America.

When former NASA Administrator Dan Goldin accompanied President Clinton to Argentina in October 1997, a Memorandum of Understanding was signed for U.S. launches of the series of Argentine SAC satellites. SAC-B was actually launched first, in November 1996, but was lost on launch. It was designed to study solar and astrophysics. SAC-A was launched from the Space Shuttle on the STS-88 mission in December 1998. It acquired more than 600 images of the Earth, and was active for seven months. The satellite tested solar panels that had been designed by the Argentine National Atomic Energy Commission, and it also collected geomagnetic data.

SAC-C was launched in June 2000 on an American Delta rocket, and is Argentina's contribution to NASA's overall Mission to Planet Earth project. SAC-C will be part of the Morningstar constellation of satellites, which also includes Landsat 7, Earth Observing Satellite-1, and the Terra satellite.



Space Activities Commission of Argentina, CONAE

Argentina has developed and built a series of scientific applications satellites, which have been launched through a cooperative agreement with the United States. SAC-C, seen here with its antennas being tested at the Teófilo Tabanera Space Center, was launched in 2000, and focusses on Earth remote sensing.

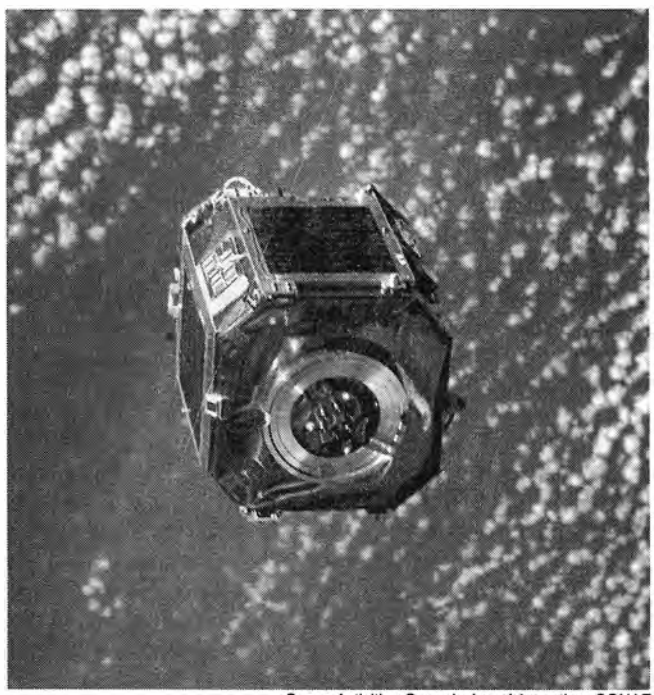
But, of course, Brazil and Argentina were not the only countries in Ibero-America interested in joining the space age.

Peru, Homeland of Pedro Paulet

Peru's contributions go as far back as the experiments and designs of Pedro Paulet at the end of the 19th Century. Peru early on recognized its "privileged position" in regard to the geomagnetic equator, and the System of the Peruvian University was created to exploit its geographical position. Peru also made a contribution to the first Apollo missions to the Moon, through observations and measurements of the consistency of the lunar soil from the Jicamarca Radio Observatory, near Lima.

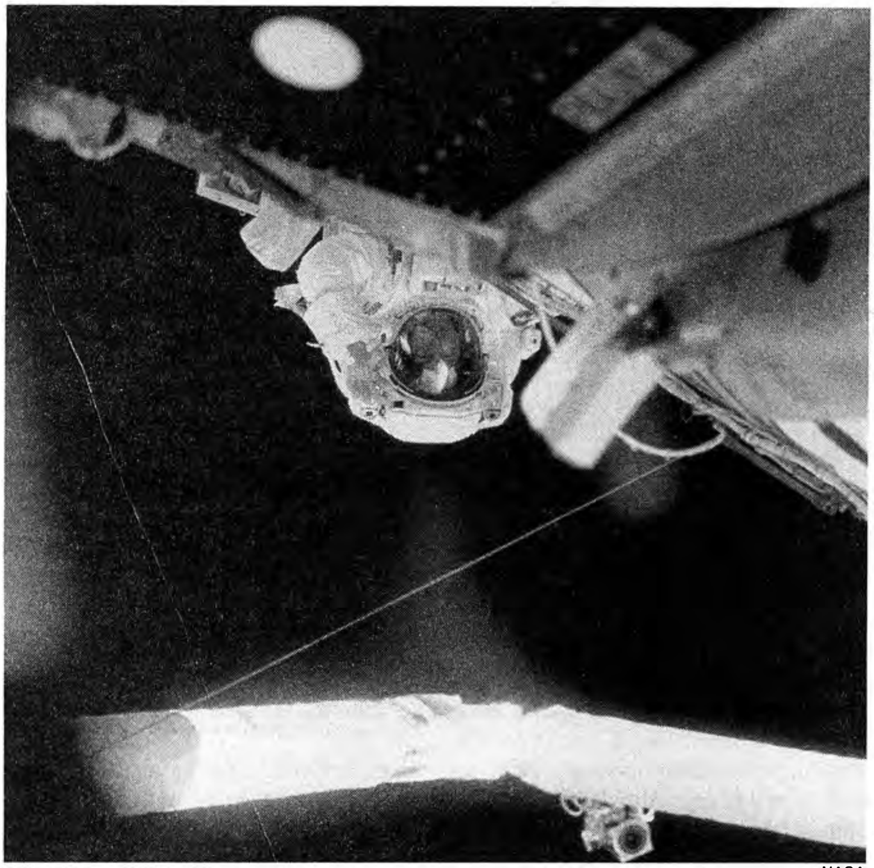
In 1972, at the IV International Symposium of the "Aeronomía Ecuatorial," held in Nigeria, the recommendation was made to the Peruvian government to establish a scientific rocket-launching base for gathering ionospheric data, to complement that obtained through the Peruvian Huayao Observatory, which is only 3.5 km from the magnetic equator. Peruvian authorities accepted the recommendation and proceeded to build the Punta Lobos launch base, 70 kilometers south of Lima, on the same magnetic meridian as the Jicamarca Observatory, which is 12 degrees South, only 1 degree from the magnetic equator.

In May 1974, the first rocket launching took place, to study the perturbations in the ionosphere along the magnetic equator. On June 11, the same year, the Peruvian government created the National Commission on Aerospace



Space Activities Commission of Argentina, CONAE

This photograph of SAC-A was taken just moments after it was released from the Space Shuttle Endeavour, in December 1998. For seven months, the satellite took photographs of the Earth, and tested new technologies for future generations of Argentine satellites.


NASA

Peruvian-born astronaut Carlos Noriega waves at crew members inside the Space Shuttle Endeavour during a space walk in December 2000. Argentina-born NASA astronaut, Fernando Caldeiro, has worked at the Kennedy Space Center since 1991, and was selected an astronaut candidate in 1996. He is waiting for his first flight.

Research and Development (CONIDA), as the space agency of Peru.

The Center for Systems and Information Processing was established to carry out the digital processing of remote-sensing images. Peru has undertaken studies on the recession of glaciers, the Amazon River, the risk from volcanoes, and coastal mapping.

CONIDA carries out reseach and development in the area of rocket technology, and plans to develop small- and medium-sized launch vehicles, along with other space agencies. Studies in aero- and gas-dynamics are under way for vehicle design, and the physical production of rocket parts and assembly, in coordination with national industry. is planned.

In 1995, the Center for Space Studies was created, to carry out an academic program in order to train professional in the use of space technologies. These include the processing and interpretation of remote-sensing images for the full array of applications, from geology and geography, to specific areas such as fishing and oceanography, and monitoring borders and clandestine airports. There are over 200 students receiving training there each year.

Through an agreement with the National University of Engineering, CONIDA is developing a masters degree curriculum in aeronautical engineering. But Peru's interest in aerospace engineering is not just academic—under development is Conidasat, a 200-kg minisatellite, which design and construction is being undertaken entirely by CONIDA. Condisat's mission will be daily observations of Peru, providing panchromatic images as it travels in a polar orbit, from south to north. Conidasat is being designed to be compatible with a range of launch vehicles, including the American Pegasus and the European Ariane.

The objective of the project is to acquire experience in all phases of satellite design, construction, testing, and integration. It will bring another Ibero-America member in to the "club" of space-faring nations.

Peru has another important link to space exploration, Peruvian-born Carlos Noreiga. Noreiga and his family moved to the United States when he was five years old. After a career in the Marine Corps, Noriega was selected as a NASA astronaut, in December 1994. In 1997, he flew on Space Shuttle mission STS-84, which docked with the Mir space station. On STS-97 in 2000, Noriega performed 19 hours of EVAs, or space walks, outside the International Space Station, installing its solar arrays. He is currently assigned as back-up commander for the sixth Expedition crew for the space station.

In an interview before his flight to the ISS, Noriega was asked about the station's importance. "We went to the Moon, and then we haven't gone anywhere else," he said. "But we really haven't developed sufficiently the technologies to come up with better ways to counteract the effect of weightlessness on the human body. . . . We need to be able to travel farther, and in my mind, that's the biggest benefit we're going to get."

Chilean Space Plans

Over the last decade, Chile has taken an increasing interest in joining the space-faring nations. Chile has focussed on developing its own satellite capability, and sharing the achievements of space development within its scientific and academic communities. In 1994, the Chilean Air Force signed a contract with Surrey Satellite Technology, Ltd, in Britain to build its first microsatellite, FASat-alpha. The goal of the 50-kg satellite project, was to create a group of engineers with aerospace experience, and to install and operate a Mission Control Station in Santiago. FASat-alpha was launched in August 1995, but unfortunately, the spacecraft failed to separate from the Russian launch vehicle and never attained orbit.

FASat-Bravo, also built with Surrey, was launched in July 1998, and orbited the Earth 14 times a day, for three years.

NASA

Physicist Rodolfo Neri accompanied a Mexican communications satellite aboard the Space Shuttle Atlantis as a payload specialist in 1985. Mexico needs a space agency in order to formulate and carry out research and experiment projects today, and to join with an Ibero-American space agency to meet long-term goals, for the future.

Through its Ozone Layer Monitoring Experiment, the spacecraft obtained a total of 1,273 images of Chile, which were shared with NASA and various universities that are studying the ozone layer.

In August 2001, a civilian space agency was established in Chile. It plans, over the next 10 years, to develop a mini-satellite for communications, and in 15 years, a geostationary satellite for domestic communications, making use of international cooperation.

The Mexican Mission

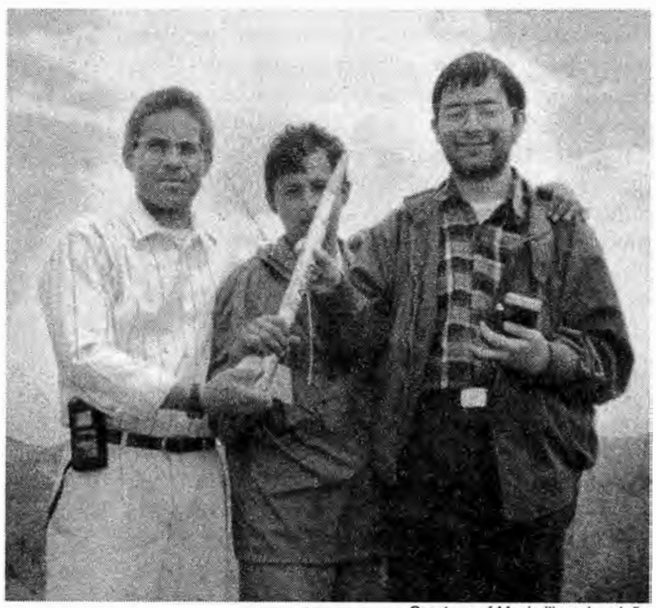
Throughout Ibero-America, there has always been a broad-ranging interest and excitement about space, particularly among young people. As early as 1962, Mexico had an amateur space society which became a member of the International Astronautical Federation. In that year, President Adolfo López Mateos signed a decree establishing the National Commission for Outer Space. But the Mexican space exploration program was never adequately funded, and in 1977, the Commission was cancelled. In 1988, a small Management for Space Affairs Office was also disbanded.

Mexico joined the international satellite communications consortium, Intelsat, in 1968, to gain access to space for domestic television and other services, and in 1980, President José López Portillo decided to procure Mexico's first two communications satellites. The government estimated at that time there were more than 14,000 remote towns and villages without telephone service. In 1985, the Morelos satellite, built by Hughes, was launched for Mexico from the Space Shuttle.

At that time (before the Challenger accident), NASA occasionally flew payload specialists along with a specific payload, and the Mexican government was invited to select and fly an astronaut to accompany the Morelos 2 satellite on the Space Shuttle. When applications were solicited, 1,500 students and professionals in medicine, engineering, physics, and mathematics volunteered. Rodolfo Neri Vela was chosen, and the Mexican government paid NASA $10 million for the flight.

During his Shuttle mission, Neri, who has a doctoral degree in physics, carried out a number of experiments, including examination of the effects of microgravity on the reproduction of *Escherichia coli-B* bacteria, the transport of nutrients in plants, electroconductance in specific areas of the body, and the effect of weightlessness and light on the germination of seeds. He also took photographs of Mexico from space.

Interest in space has continued to flourish in the universities of Mexico. In 1995, a 50-kg satellite developed at the Autonomous University of Mexico, UNAM, was built, to obtain data on volcanic particles and meteor trails in the upper atmosphere. The satellite was lost in a Russian rocket failure. UNAM's second small satellite, weighing only 17 kg, was successfully launched in 1996, to research small meteorites.



Courtesy of Maximiliano Londoño

Maximiliano Londoño, (left) head of the Ibero-American Solidarity Movement (MSIA) in Colombia,.founded the Association to Promote an Aerospace Agency in Colombia, with students and professors in colleges and universities in Bogota, Here Londoño and colleagues Carlos Orlando Parra and Edgar Espejo display one of the rockets their space society was getting ready to launch.

Recently, a feisty group of space enthusiasts and young people has been encouraging the Mexican government to re-establish a space agency, and join other Ibero-American nations in space exploration. The Mexican Space Society was formed in 1990 through the energetic organizing of Jesus Raygoza. The group has worked with Mexican schools to develop a space science curriculum, and has worked on amateur rocket projects.

Raygoza has presented documents to the Energy Commission of the Mexican Congress, proposing the creation of Mexican space research facilities, and possible spaceports for launches. In 1995, the Mexican Space Society submitted a formal proposal to the government for the formation of a space agency, and in March 1998, it testified before a hearing on the Congressional Committee on Science and Technology

In an interview in 1999, Raygoza stated, "To return to the Moon and send people to Mars . . . are not merely the theoretical goals of a handful of space scientists, but a necessity for civilization today, if it wants to guarantee its long-term future developemnt." He likened space exploration to the undertaking by the King of Castille in the 15th Century, in sending out Columbus, which ended with the conquest of America.

"Our civilization is deteriorating," Raygoza said, "and if we don't develop economically, in the long term, we are going to sink." The Mexican Space Society continues to promote this idea, which would undoubtedly gain support, were there an Ibero-American space agency.

Similarly, in Colombia, an enthusiastic group of university students and professors have formed the Association to Promote a Colombian Aerospace Agency. Participants from the National University, Universal District and Antonio Narino, and the University of San Buenaventura have built and launched amateur rockets, and are studying the physics, chemistry, and other sciences required for a space program.

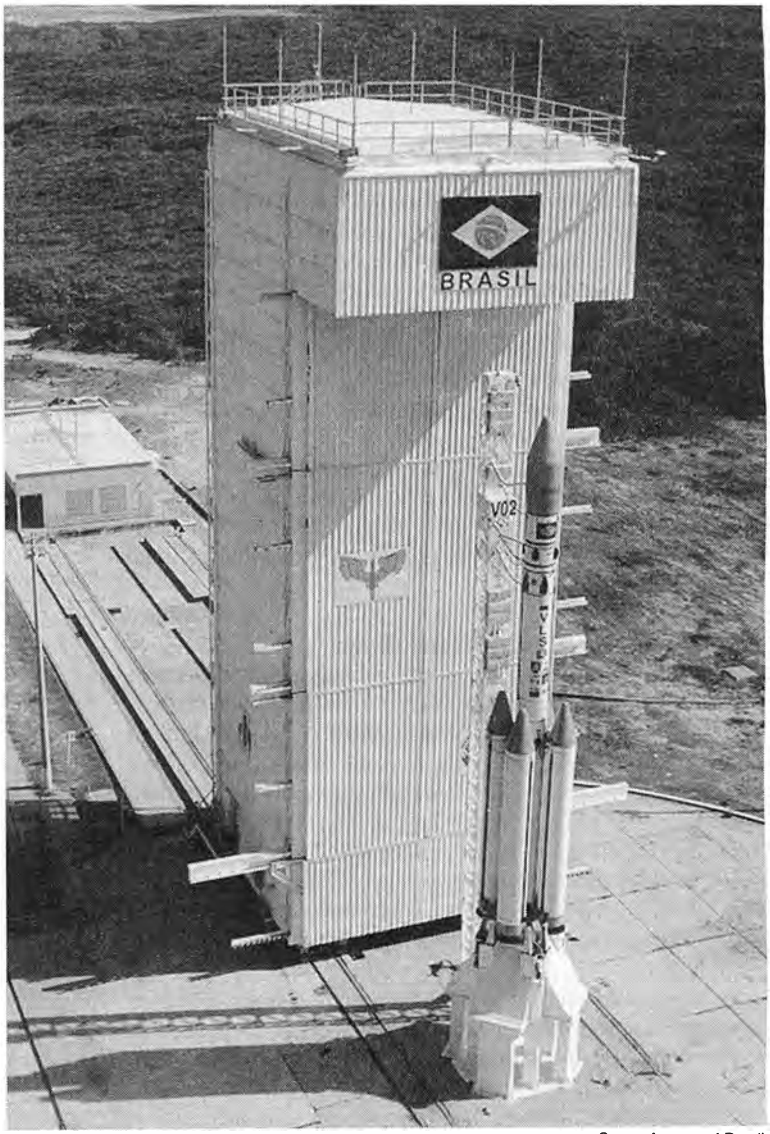
The Fight to Launch

From the very beginning of Ibero-America's participation in space exploration, both Argentina and Brazil were developing their own rockets. A rocket-launching capability has been rightly seen as a national security and sovereignty issue, as well as an economic one. By 1994, Mexico, for example, had spent $579 million for its satellite communications system, largely paid to foreign companies to build and launch its satellites. Argentina and Brazil were determined to develop their own domestic space industries.

Both Argentina's and Brazil's rocket programs grew out of their early sounding rocket campaigns. Both used the small-scale rockets as the building blocks for multi-stage launch vehicles, with the goal of using indigenous rockets launched from domestic launch sites, as is done by the United States, Russia, Europe, Japan, India, and China.

Throughout the 1960s and 1970s, the Argentine military developed a series of ever more capable rockets, and in 1982, it began development of the Condor II. This was a two-stage solid-fueled rocket, designed for a payload of 450 kg and a range of 800 to 1,000 kilometers.

For much of its fledgling rocket technology, Argentina relied on help from abroad. After the Malvinas War, fought with Britain in 1982, the Argentine government decided that although it would still have to obtain certain components abroad for the Condor II, local industry should be developed and relied upon, as much as feasible. The military's stated goal in the Condor II program was to be able to place payloads,



Space Agency of Brazil

The VLS rocket on the launch pad at the Alcântara launch site in Brazil. The VLS is Ibero-America's only remaining indigenous rocket, following the U.S.-led success in ending Argentina's Condor program. Further developing the technology and testing of the VLS should become a principal joint project of an Ibero-American space agency.

military and civilian, into Earth orbit, and to advance vanguard technologies, with applications in both the military and civilian aerospace field.

The Condor II was also a joint project, in which Egypt was to be involved in the production of the launcher, (called the Vector), and Iraq was providing the financing for the Middle East project, known as Badr-2000 in Iraq. A consortium of mostly European firms handled various portions of the Condor II project, and more than a dozen U.S. firms were directly involved.

Also, in the 1980s, during the Iran/Iraq war, the Brazilian private company Avibras began marketing multiple rocket launcher artillery systems derived from its Sonda sounding rockets, to Iraq, Saudi Arabia, Bahrain, and Qatar. But it became clear that the world's major arms producers, with the United States in the lead, were not going to stand for any competition in weapons sales, especially to the Middle East.

In truth, the "missile race" in the Middle East began not during the war between Iran and Iraq, but in 1961, when Israel launched its Shavit rocket. After the 1967 Middle East war, France slapped on an embargo, but the United States assisted Israel in developing warhead and guidance technology, and Israel developed its own Jericho missile, and deployed it in 1968.

'Non-Proliferation,' Again

As early as 1972, the United States banned the export of launch vehicle technology to Brazil, in the hope that this would kill its rocket launcher program. In the mid-1980s, the space powers made their move to shut off all technology transfer to any country that refused to stop development of rocket launcher systems.

In 1982, following the Iran-Iraq war, President Ronald Reagan signed a National Security Decision Directive to investigate ways to control missile proliferation. In 1985, the Group of 7 advanced industrial countries initiated talks, and in April 1987, the United States, Britain, France, West Germany, Italy, Canada, and Japan made public the Missile Technology Control Regime (MTCR), a supposedly "voluntary arrangement."

What gives the immediate lie to the claim that this Regime was intended just to stop weapons proliferation, is the fact that it defines "missiles," to include space launch vehicles that would be used for commercial purposes, and sounding rockets, that are used for scientific experiments. The signatory countries agree not to export, not only rockets, their production facilities, and systems, but also a wide range of "dual use" parts, components, and subsystems, like propellants, structural materials, test equipment, flight instruments, and so on. As in the Nuclear Nonproliferation Treaty, the MTCR states that the agreement is "not designed to impede national space programs or international collaboration in such programs," but then admits that "the technology for a space launch vehicle is virtually identical to that used in a ballistic missile"—banning technology transfer for all rocket programs.

Because the nuclear powers insisted that Ibero-American countries wanted to develop nuclear weapons, they could now claim that their rockets were just the delivery system for such "weapons of mass destruction."

The MTCR crippled Ibero-America's space launch programs, by preventing the export of technology. As an "agreement" that is not a treaty, the MTCR does not impose sanctions on countries that violate the regime, and export "missile" technology. But U.S. protests and pressure on the other signators led to Italy's withdrawl of support for Argentina's Condor program, and in 1989, France finally capitulated and ended its offer to send its Viking liquid-fuel rocket technology, and experts, to Brazil.

The United States *did* apply sanctions unilaterally against countries in Ibero-America, as it has also done against Russia's space enterprises for their cooperation with Iran, and against Pakistan, for receiving assistance from China. These sanctions, and the broader pressure from the MTCR, helped slow the VLS launch project in Brazil, and ended the Condor II project in Argentina.

Condor Cancelled, but Brazil Resists

In April 1990, Argentine Defense Minister Humberto Romero stated that the Condor program had been "suspended and frozen." He stated that although the Condor rocket was intended as a satellite launcher, it was "paralyzed" by the international political assault, so a political decision had to be taken to stop it. In addition, he said, Argentina did not have the funds to continue. The International Monetary Fund promised the debt-burdened country new loans, if it would abandon its missile program.

Great Britain was "concerned" that the Condor II would allow Argentina to strike the Malvinas. Israel was concerned that the Egyptian and Iraqi ties to the project threatened to spread missile technology throughout the Middle East, although only Israel itself had such capabilities. At the same time that the political pressure mounted, the financial situation was reaching a breaking point, and Foreign Minister Domingo Cavallo assured the United States that Argentina would kill the Condor program. In return, he expected help from the U.S. with the IMF, World Bank, and private bank negotiations. How successful Cavallo's approach was then, or more recently when he returned for a stint as Treasury Minister, is evident in the bankruptcy of Argentina today.

In 1991, Argentina became a signator to the Missile Technology Control Regime, and in April 1992, it bowed to the enormous pressure, and handed over most of the components from the Condor program to be destroyed. In 1991, the civilian Argentine Space Activities Commission, CONAE, was established, in order to open the door to increased cooperation with NASA in the United States.

Brazil refused to buckle under the pressure, even though by 1992, the Brazilian Air Force announced that as a result of the sanctions, the VLS program was being seriously delayed. Because it could not gain access to the fuel component, inertial guidance, reentry, and other technology needed to continue development of the VLS, Brazil was forced to develop its domestic research and industries, or abandon the project.

Again, as in the case of nuclear energy, if the goal were actually to prevent rocket technologies from maturing in Ibero-America, the sanctions policy failed. It just forced nations to develop these industries internally, although more slowly, without international assistance. The assumption that a technology blockade would kill Brazil's rocket program was foolish to begin with. An article published in the October/November 1997 issue of *Air & Space* magazine reminds the "nonproliferation" mafia that there is a "myth" that the VLS could not be a success "without a von Braun," that is, an outsider.

But, the article states, the Brazilian space program has its own fathers, including Jayme Boscov, who worked in France on the Concorde and came back to Brazil to start the program that created the Sonda and VLS; and João Verdi de Carvalho Leite, who was the president of Avibras.

To show its intentions, in 1994, the government of Brazil created a civilian space agency (AEB), which said it would abide by the MTCR guidelines. Proliferation "experts" even admitted that Brazil had made "a pretty credible case that there was never a missile."

The United States agreed to join a campaign to launch 30 sounding rockets from the Alcântara launch site in 1994, as a carrot to lure Brazil into formally joining the MTCR. In October 1995, the Brazilian Senate enacted a bill that imposed export controls on launch materials and six days later, the MTCR members states voted to accept Brazil, on the condition that its missile projects be terminated. No country that was a non-missile state before 1987 had been allowed to join the MTCR without agreeing to destroy its rocket program.

But Brazil would agree to no such thing. Eventually, the Clinton Administration accepted Brazil's pledge that it would not develop the VLS as a missile, having lost the fight with Brazil over its development as a commercial launch vehicle. The U.S. had to swallow its regulations, and admit Brazil to the MTCR as the only nation that had not tested a rocket before 1987, but did not have to physically destroy its program.

The first test flight of the VLS took place in November 1997, but one of its four engines failed, and the rocket was destroyed. The second test flight, in December 1999, which carried the $6 million SACI-2 satellite, was destroyed, because of a second launch failure. This is not unusual at the start of a rocket test program.

Since the promulgation of its Complete Brazilian Space Mission in 1980, Brazil has planned to complete development of a commercial space launcher, to become self-sufficient in sending spacecraft into Earth orbit. Although that effort has been delayed, it is under way. The third test of a VLS vehicle is now scheduled for October 2002, and a fourth test is planned.

Recently, a Brazilian delegation led by President Fernando Henrique Cardoso visited Russia, and a Russian delegation is expected to visit Brazil by the summer of 2002. Discussions will include the development of liquid-fuel propulsion technology for the next generation of Brazil's launchers, after the VLS test program. Such high-energy upper stages will increase the payload capability of Brazil's rocket launcher.

The third goal of the Complete Space Mission is the ability to launch Brazilian-made satellites, on Brazilian-made rockets, from a launch site in Brazil. But here, again, there has been a frontal assault from the United States.

An Ibero-American Spaceport

On October 16, 2001, the *Washington Post* reported a statement by the President of the Brazilian Space Agency, Luis Gilvan Meira Filho, who said, "We do not want to stay locked in the developing world forever. Our road out will be paved with science and technology. That is what Alcântara is all about."

In the 1970s, the Brazilian Air Force built a rocket launch facility at Alcântara, the capital of the state of Maranhão, on land that encompases more than five times the area of the European Space Agency's launch site at Korou in French Guyana. The $230 million facility was used for suborbital sounding rockets experiments.

In 1980, the plan was to expand Alcântara to accommodate launches of Brazil's VLS, and other nations' commercial launches of rockets and satellites. Although financial difficulties slowed progress, in 2000, Retired Air Force General Archimedes de Castro Faria Filho, director of programs at the Ministry of Science and Technology, reported at a symposium in Washington, that between 1984-1990, the new Alcântara launch center was built, at a cost of $300 million.

The state-owned airport operator Infraero is responsible for commercially developing Alcântara. In 1999, it was estimated that foreign clients would be charged about $2 million per launch to use the facility. At that time, Italy's Fiat/Avio had signed a collaborative agreement to invest $70 million in upgrades, as part of a consortium using the Ukrainian Tsyklon rockets from Alcântara. Also, Lockheed-Martin was in discussion with Brazil to launch its new Athena-3 rocket there.

More recently, it was reported in *Space News* on October 8, 2001, that the U.S. Air Force is planning to launch an experimental satellite aboard an air-launched Pegasus booster from Alcântara, in 2003.

More U.S. Pressure

But the United States has decided that regardless of its stated admission that the VLS is being developed as a commercial launcher, and the fact that Brazil is a signer of the MTCR, everything that can be done, will be done, to stop Brazil from achieving an independent launch capability. On April 18, 2000, a Technological Safeguards Agreement, required under the MTCR, was signed between Brazil and the United States, which is supposed to allow for the commercial launching of American rockets and American satellites from Alcântara. Any satellite that has even one U.S.-made component is subject to export approval by the United States for its launch.

On August 31, 2001, a document explaining the Agreement was sent to the federal deputies and senators in Brazil. On September 9, 2001, Brazilian Rep. Waldir Pires said in a report to the Foreign Affairs and Naional Defense Committee that the Safeguard Agreement should be rejected, because of its "contempt for national sovereignty." Other voices in the Brazilian legislature are urging rejection of the Agreement. Why?

The Agreement establishes restricted areas on the facility, accessible only to U.S.-approved personnel during the assembly and launch of U.S. payloads or vehicles. The Agreement prohibits Brazilian customs officials from inspecting closed containers with U.S. equipment that enter the port at Alcântara. And, most egregious, the Agreement stipulates that Brazil is not to use revenues from commercial launches for the development of the VLS! So much for the oft repeated lie that export-control regimes do not prevent the development of civilian technology.

According to the U.S. Department of State, this restriction is unique to the Agreement with Brazil, because the United States does not want any support for "new missile systems." The Department acknowledges that U.S. policy "goes beyond the MTCR regime," and admits that it does not think that "other countries will go along with the U.S." on these restrictions. The State Department recognizes this is a "sensitive political issue for Brazil," but thinks the Safeguards Agreement will pass the Brazilian Senate. That remains to be seen.

Brazil is also pursuing other options. On November 18, 1999, the space agencies of Brazil and Ukraine signed an agreement in Kiev for cooperation in space areas, including the launch of Ukrainian rockets, such as the Tsyklon, at Alcântara. A Ukrainian delegation is scheduled to visit Alcântara in the spring of 2002, according to the head of the Brazilian space agency, Mucio Dias, to determine the modifications that are required at the existing facility, and the costs involved, in order to launch Ukranian Tsyklon rockets. The project is estimated to cost between $150 and $200 million. A technology safeguards agreement has already been signed by the two nations.

Virtually as soon as the Missile Technology Control Regime went into effect in 1987, Brazil realized that it would have to broaden its scope of international cooperation in space technology in order to move forward. In July 1988, Brazilian President José Sarney visited China. The two governments signed an agreement to develop two advanced remote-sensing satellites. Brazil was to build the satellites, and China to provide some of the technology and the launch on a Long March rocket. At the time the program started, INPE made clear that Brazil intended to use the cooperation with China "to break down the developed countries' prejudice against advanced technology transfer."

In 1993, the contract for two China-Brazil Earth Remote Sensing satellites, (CBERS) was signed in Beijing. That year, President Jiang Zemin visited INPE during a tour of Brazil, and observed Brazil's satellite-building and testing capabilities, first hand. In 1995, President Fernando Henrique Cardoso visited China, and the two sides decided to enlarge the CBERS program, adding the construction of a third and fourth satellite, and an extra satellite as a transition between the two pairs.

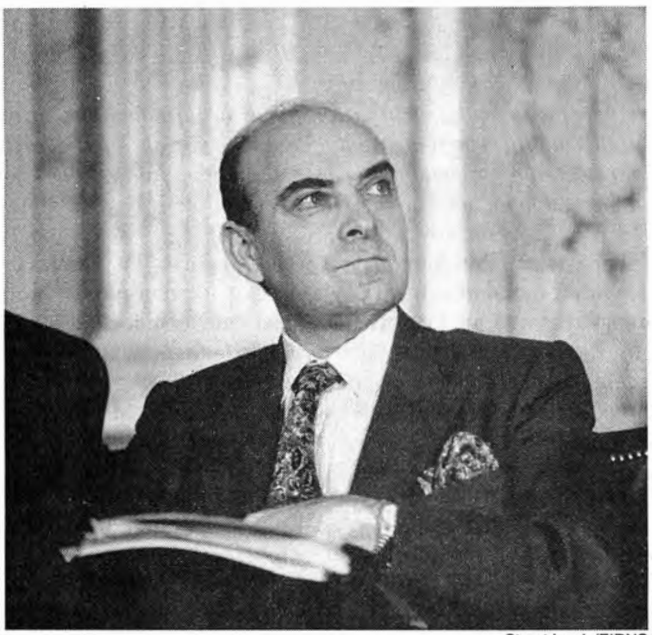
CBERS-1 was launched on October 14, 1999, and the Brazilian Ministry of Science and Technology was able to release its first image 15 days later—a swath of jungle in the state of Amazonas, in northwestern Brazil. CBERS-1 is a 3,000-pound satellite, which is controlled at the Xi'an Satellite Control Center in China. Aboard CBERS-1 is a Wide Field Imager for data in visible light, and the infrared part of the electromagnetic spectrum, a High Resolution CCD Camera, and an Infrared Multispectral Scanner. Both China and Brazil are nations with extensive territories with large, uninhabited areas, that are hard to reach. The satellite data will be used for forestry, agriculture, geology, and hydrology. Brazil hopes to compete with American and French remote-sensing systems in marketing the imagery.

The second CBERS satellite is now scheduled for launch from China in the summer of 2002.

In September 2000, Chinese Foreign Minister Tang Jiaxuan visited Brazil, and an accord was signed for the "Satellite Sino-Brazilian Project of Land Resources." This expanded the bilateral cooperation, and outlined the terms of shared cost for the two second-generation satellites. At that time, Brazilian Minister of Science and Technology, Ronaldo Sardenberg, stated that "future bilateral cooperation in technology may expand to areas such as biology, information, human genetic engineering, and agriculture."

In early 2002, Brazil signed a space cooperation agreement with India, the country most like itself, in its goal for self-sufficiency, and the level of its space technology. On March 1, Dr. K. Kasturirangan, Chairman of the Indian Space Research Organization, and Dr. Múcio Dias, President of the Brazilian Space Agency, signed a broad Memorandum of Understanding in Bangalore, India, to cooperate in space. The MOU includes programs in satellite technology, organization of training programs, and exchange of technical and scientific personnel to work together on specific issues.

At the signing ceremony, Indian Minister of State for Space, Smt. Vadundhara Raje, stated that although "India and Brazil are located



Stuart Lewis/EIRNS

Domingo Cavallo, the International Monetary Fund's man in Argentina, was forced out of the government in December 2001, after that nation's default on its debt, thanks to the policies he had promoted as Finance Minister. During his stint as Foreign Minister in the early 1990s, Cavallo threw Argentina's Condor program on the scrap heap, in exchange for the promise that international financial institutions would "help" Argentina. Cavallo was charged with "aggravated contraband" linked to illegal weapons sales and jailed in early 2002.

Space Agency of Brazil

More than $300 million has been spent by the Brazilian government to build facilities at the Alcântara launch complex in northeast Brazil for the launch of full-scale rockets. Because the United States has tried everything in its power to prevent this independent launch capability from becoming operational in Ibero-America, the Brazilian government is working with other nations, like Ukraine, to begin commercial launches from this site.

continents apart on the globe, we share several things in common. We are both large countries, with a rich endowment of natural resources. The cultural heritage that we both possess is rich and diverse. . . . Significantly, both our countries are developing nations striving to accelerate the engines of our economic growth through judicious use of science and technology." The focus of the cooperation will be on space technology applications such as communications, remote sensing, and meteorology.

While Argentina and Brazil have bilateral agreements with other countries, the most important for the future of an Ibero-American space agency is the one they have with each other. Although historical rivalries have afflicted relations between Argentina and Brazil for a long time, in 1989 the presidents of both countries signed the Joint Brazilian Argentinian Declaration on Bilateral Cooperation in the Peaceful Uses of Space. Under this framework, in 1996, they signed a government-to-government agreement for cooperation in space science, technology, Earth resources and environmental studies, and made a commitment to develop combined satellite missions and means of access to space and launch services.

In his October 2000 speech calling for a "space agency for South America," Dr. Varotto of the Argentine space agency stated that Argentina is cooperating with Brazil in an "economic/technical feasibility study for the development of a satellite launcher that satisfies the orbital and payload requirements of the space missions of [Argentina's] National Space Program, using at least, a high-efficiency liquid stage." Although Argentina gave up its Condor II program, it has not given up on the importance of an Ibero-American space launch capability. "The Argentine determination of working with Brazil in this field cannot be more explicit," Varotto stated, referring to Brazil's VLS.

Argentina and Brazil currently mutually support tracking and telemetry and control of each others satellites. Argentina has also used the test facilities at INPE in Brazil for its satellites. Together, both countries are designing the Argentine-Brazil Satellite for Investigations in Food, Water, and Environment, or SABIA (see p. 53). It will be a $30 million, 350-kg satellite, with a multispectral scanner in the visible and near-infrared, providing a ground resolution between 6 and 8 meters. Every three days, SABIA will cover the entire Mercosur region of Argentina, Brazil, Paraguay, and Uruguay.

Dr. Varotto says that for Argentina, "Brazil and Argentina have a very good opportunity to work together on the

Mercosur Space Agency organization. Even more, the Agency may incorporate member states in advance of their incorporation to Mercosur. But to do so, it is our opinion that we should consider seriously the design of a Common Space Program, starting with Brazil and Argentina, with common objectives."

One objective must be to broaden Ibero-America's participation in manned space flight.

Brazil's Bold Move Into Space

The ultimate goal of space technology development is to enable the exploration of space by men. In this, Brazil has taken a bold step.

In 1982, President Ronald Reagan made an offer to Brazil to fly an astronaut on the Space Shuttle. While such plans were put on hold after the Challenger accident, Brazilian scientists did participate in important protein crystal growth experiments that have flown on seven Shuttle missions. On the first, mission STS-83 in 1997, the Second-Generation Vapor Diffusion Apparatus carried eleven proteins in its experiment chambers, including two proteins related to Chagas disease. The group of investigators working on this project included scientists from Argentina, Brazil, Chile, Costa Rica, Mexico, and Uruguay.

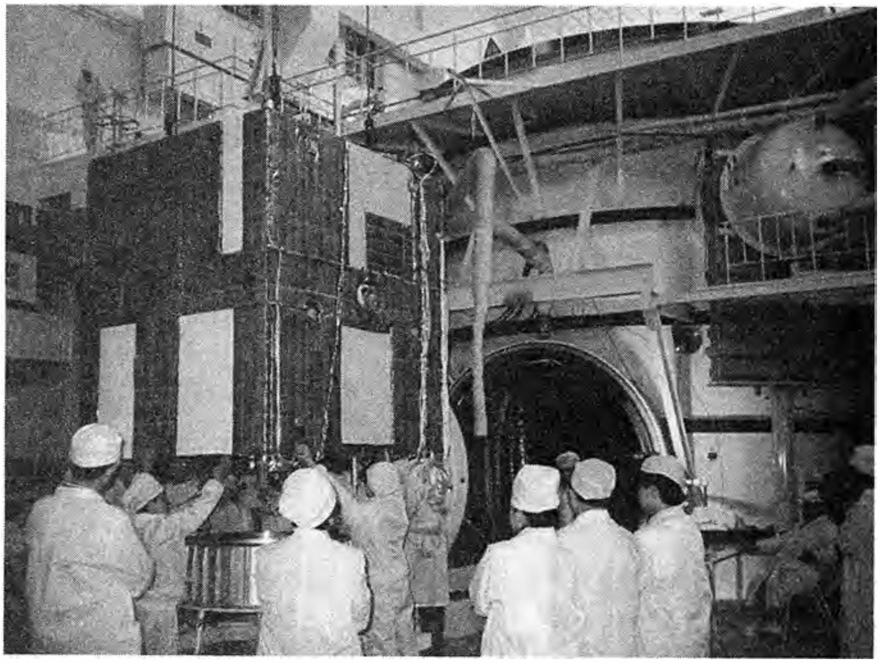
Brazil was interested in both extending the research in protein crystal growth on the International Space Station, and also making a substantial contribution, in exchange for which, it could fly an astronaut on the space station.

In December 1996, Brazil was invited by NASA to join the space station program as a participant, and when Administrator Dan Goldin accompanied President Clinton to Brazil in October 1997, NASA and the Brazilian space agency signed an implementing agreement, for the "Design, Development, Operation, and Use of Flight Equipment and Payloads for the ISS." The object of the agreement was for Brazil to produce pieces of hardware for the station, and in return, to have access to research facilities on board, or "utilization rights," and the opportunity for a Brazilian astronaut to live on the station. One benefit that Brazil saw in this arrangement is that its universities and research centers would be able to cooperate with those of other countries. And Brazilian industry would have to qualify its industrial processes according to rigorous manned space flight standards. Because NASA's budget was increasingly unable to fulfill all the U.S. commitments to the station project, Brazil would be contributing important hardware, which the United States would then not have to build.

Brazil agreed to build four major types of hardware for the space station. The first is an EXPRESS Pallet (for Expedite the Processing of Experiments to Space Station). EXPRESS is a structural support which attaches small payloads to the U.S. external truss segments of the station. Brazil is to supply four units, each of which can accommodate up to six experiment

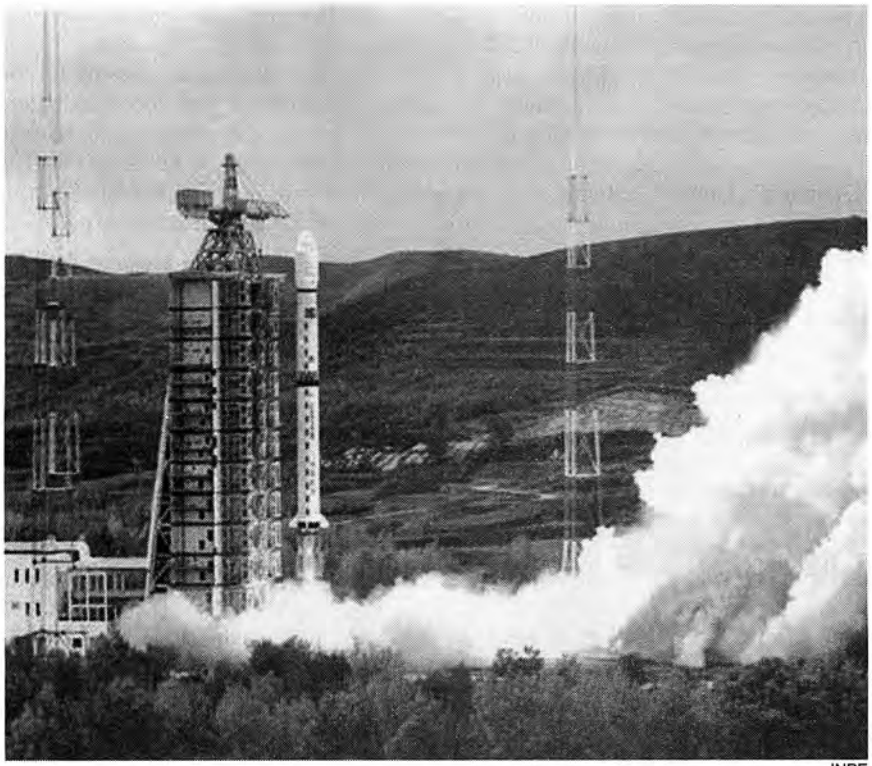
INPE

In 1993, Chinese President Jiang Zemin (left) visited the engineering facilities at INPE in Brazil, to observe satellite design and construction activities for the joint China-Brazil Earth Remote Sensing satellite. Brazil's decision to cooperate with China in space technology, is part of its attempt to develop more advanced space systems, despite the U.S. policy interference.



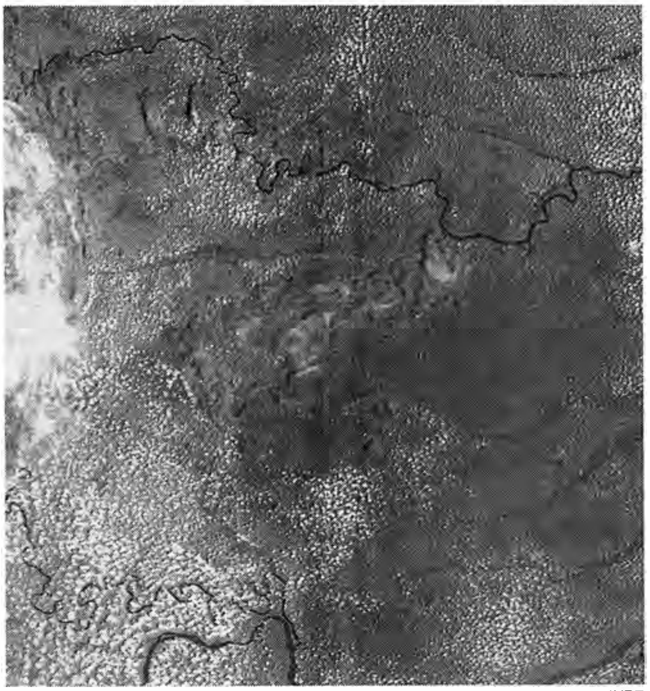
INPE

Before its launch on from China's Taiyuan launch center, the Brazilian-made China/Brazil Earth Remote Sensing satellite underwent acoustic testing at the Chinese Academy of Space Technology.



INPE

CEBRS-1 was launched on October 14, 1999, aboard a Chinese Long March rocket, as the first fruit of the China-Brazil space cooperation agreement.



INPE

The first image taken by the Wide Field Imager aboard CBERS-1 one week after the launch of the satellite. On the top is a section of the Valpes River, and near the bottom, of the Jupura River, southwest of the State of Amazonas. The image covers an area of 300 sq kilometers.

payloads, for a total of 1.36 tons. The EXPRESS Pallet supplies power and data to each of the payloads.

The Technology Experiment Facility (TEF), is hardware to also accommodate experiments on the external structure of the space station, providing long-term exposure to the space environment for payloads. Brazil is to supply one unit, which can be moved from the cargo bay of the Space Shuttle, via the Shuttle's robotic arm, to its position on the truss. Brazil is also to provide the Window Observational Research Facility Block 2, which will be used as a mount for optical instruments at the window, for Earth observation. Different scientific instruments can be mounted behind the window at different times. Four Unpressurized Logistics Carriers are also to be built by Brazil, to carry spare parts and maintenance equipment. They will be mounted on the truss and make available tools and equipment that can be stored in space.

In exchange, the Brazilian space agency is entitled to experiment time, using space station equipment, and to room in the Space Shuttle to ferry experiments up to the station, and back to Earth. Brazil will have available, for example, the use, for one year, of a rack inside the station, where its experiments can be placed. Also available will be 3 percent of the operational time available at the observation window.

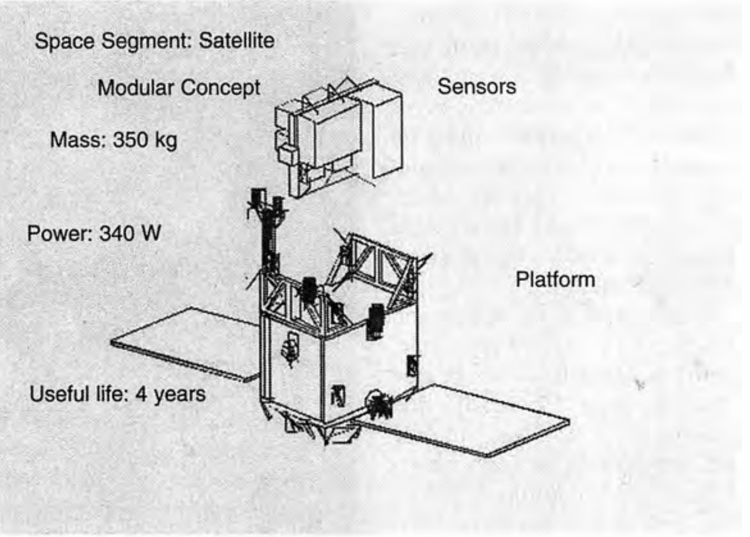
NASA will provide for one Brazilian Space Agency station crew member for one increment (three or four months of living on the station). Brazilian Air Force Major Marcos Pontes reported to the Johnson Space Center in August 1998, to begin his training for a space station mission. Pontes is a test pilot, who has flown 20 different types of aircraft. He had graduated from Naval Postgraduate School in Brazil, when he was selected for the astronaut program. He is currently working in technical assignements in the Astronaut Office, until he is assigned to a space flight.

Such commitments, running in the hundreds of millions of dollars, have not been easy for Brazil to meet, because of the worsening spiral of debt payments, financial crises, and resulting budget cutbacks.

In September 1998, the first contract was signed between INPE and the Boeing Company, to act as a subcontractor for the Brazilian space station hardware. The Brazilian Space Agency had delegated INPE to oversee the station work. Brazil was to pay Boeing up to $10 million to provide oversight of the design and integration of the hardware. It was estimated that it would cost about $120 million to meet Brazil's hardware commitments.

But in early 1999, the Brazilian central bank removed regulatory constraints and allowed its currency to float, reducing the value of the *real* compared to the U.S. dollar by 30 percent. The International Monetary Fund required the country's leaders to implement severe budget cuts and austerity, leading to cuts in the space agency's budget for the International Space Station. By mid-year, Boeing, which was not being paid, removed its consultant and closed its office in Brazil. Brazilian officials warned that such behavior could damage a 15-year relationship with INPE. "If you want to establish and maintain a long partnership, you don't act like that during the first thunderstorm," stated INPE Director Marcio Nogueira Barbosa. But if Brazil were not to deliver the hardware, NASA would have until the end of 1999 to find another supplier.

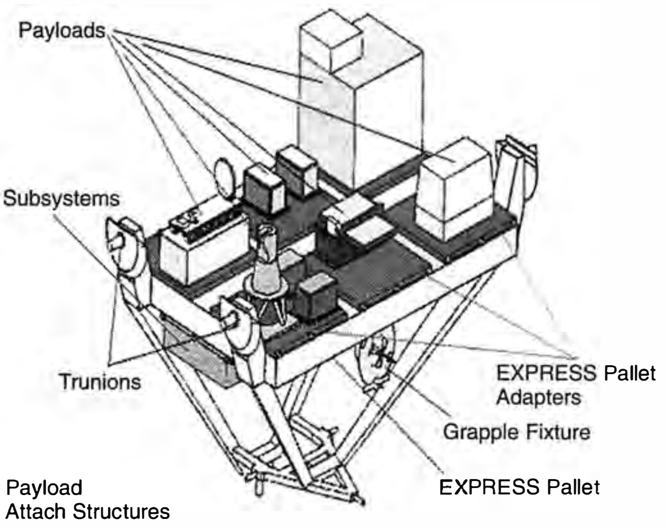
On October 6, 1999, NASA officials met with the Brazilian Minister for Science and Technology, who assured NASA that Brazil would meet its obligations for the space station. "We may have to make cuts in other ministries," he said, but the government considers the project important. The executive branch asked the legislature for $23 million for the next year, reversing earlier year 2000 budget plans that did not include that request. In December, Brazilian officials told NASA that they were resuming station work, and Boeing was paid the $3 million it had been owed for work on the EXPRESS Pallet.



Space Activities Commission of Argentina, CONAE

The first space project developed jointly by two nations of Ibero-America will be the remote-sensing Argentina-Brazil Satellite for Investigations in Food, Water, and Environment, or SABIA. It will be based on a modular platform concept that can then be utilized for other satellites. Although each nation has specific remote-sensing requirements, the joint satellite allows each country to take advantage of the advancements of the other.

In January 2001, Brazilian aircraft manufacturer Embraer was awarded the contract to begin construction work on the EXPRESS Pallet project, based on the feasibility study it had conducted. At that time, the projected launch date for the first pallet was 2003, with a total cost of $120 million, spread over four years.



NASA

The EXPRESS Pallet (for Expedite The Processing of Experiments to Space Station) is Brazil's primary contribution to the International Space Station—the first by a developing nation. Although a series of financial crises has slowed the timetable for delivering the hardware, Brazil is determined to meet its commitments and remain in the space station program.

Recently, another setback arose in the program. At the end of 2001, Embraer's bid to build the hardware was reportedly 50 percent higher than the $120 million projected cost. According to the Brazilian Space Agency, negotations are now being held, which "could lead to a revision of the proposal" Embraer has made. Embraer's bid estimate is being carefully examined.

According to NASA, there will be a meeting with Brazilian representatives in the early spring, to make a decision about Brazil's ability to supply the hardware. Because the EXPRESS Pallet is infrastructure to be used by all of the space station's participants, NASA must ensure that it is completed. Slippage in the overall station schedule, largely as a result of Russian, and now American, budget problems, has forced a delay of the launch of the Pallet to 2005. The NASA official stated that the "whole space station program is in a major state of flux," as a result of the U.S. budget problems, and they "want to keep Brazil in the project."

Brazil made a bold and daring decision to be the first "developing" nation involved in manned space flight. It is a crucial first step, to open this vast and challenging frontier, with all of the benefit such exploration will have, for all of the nations of Ibero-America.

Every Child, An Explorer

If the infrastructure and capabilities for space exploration of all of the nations of Ibero-America were coordinated, a broad-scale, full-scope space program would emerge. Ibero-America, with little if any help from other nations, could design, build, test, and soon, launch satellites. Argentina's experience with its Condor launcher program should be applied to the remaining development for Brazil's VLS. This rocket should be available to launch payloads for all Ibero-American nations.

Small satellite development, taking place in at least Chile, Peru, and Mexico, can be the stepping-stone for small- and modest-sized satellites, not only for applications in Earth observation and communications, but, also in space science. Why not apply the scientific instruments and data processing facilities developed for Ibero-America's extensive Earth remote sensing projects, for example, to studying our next-door neighbor, the Moon?

By combining the physical, scientific, and human resources of this entire region, an Ibero-American Space Agency could become a full-fledged partner in manned space flight, while it is also developing the ability to reach out farther into space on its own.

The choice of paths could not be more clear. Continued adherence to the dictates of the bankrupt International Monetary Fund will mean more misery, and no future. The alternative is the revolution in education, infrastructure, and economic technological growth that would be the result of an aggressive space exploration program. The outstanding example of such an effect is the American Apollo program in the 1960s. It created a generation of new scientists engineers; a demand for basic industrial goods that required investment in electricity, transportation, and machine tools; and the technical challenges that forced the introduction of new technology into industry, even continuing for two decades after NASA had spent the money to take men to the Moon.

NASA

There is nothing more inspiring for a young person than to see someone who is "like them" carry out exciting tasks in space. Air Force Major Marcos Pontes, an astronaut from the Brazilian Space Agency, has been training with NASA as a Mission Specialist since 1998, preparing to take his turn living on the International Space Station. Pontes is an example to all young people in Ibero-America that they too can participate in the great adventure of space exploration.

The major problem is not financial, or a lack of capital and human resources for Ibero-America to carry out great projects in space. The major challenge is the fight that must be won for the ability of each human being to be enabled to make scientific and economic contributions to his country, and for the leadership of nations, to carry out policies based on their sovereign self-interest.

In 1997, internationally renowned American economist Lyndon LaRouche spoke before an audience of 500 people, in Lima, Peru, and addressed this question. LaRouche said: "Never accept the idea that certain natons are rich and others poor. Never accept the idea of being a poor country. Never conceive of yourselves as persons from a poor country. I ask you to turn your eyes to the stars, to see with pride and confidence what the mind makes you capable of achieving. Forty years from now, which is not so far away . . . the children of some of the youngest members of this audience will walk on the surface of Mars. The sons and grandsons of some of the poorest rural families of Peru today will walk on Mars."

Marsha Freeman is an Associate Editor of 21st Century. *Her most recent book,* Challenges of Human Space Exploration, *was published by Springer Praxis in 2001.*

Notes

1. Varotto made his forceful proposal in Rio de Janiero, Brazil, at the Congress of the International Astronautical Federation (IAF), titled, "Space Activities in South America." In his speech, Dr. Varotto noted "the possibility of shaping, in the not-distant future, a Mercosur [Common Market of the South] Space Agency, with its prospective extension to other interested South American countries." The permanent members of Mercosur are Argentina, Brazil, Paraguay, and Uruguay; associate members are Bolivia and Chile.

   Although bilateral space cooperation agreements already exist between Argentina and Brazil, Dr. Varotto explained, joint activity up to the present time has been based on the "coincidence" of activities and projects being persued in each country. What is needed are "common specific and detailed objectives," from which new joint programs would be organized. Dr. Varotto stressed that it is "a key point to incorporate other South American countries into associative space cooperation with Argentina and Brazil."

2. National Security Study Memorandum 200, titled "Implications of worldwide population growth for U.S. security and overseas interests," was drafted under the direction of Ford administration officials Henry Kissinger and Brent Scowcroft in 1974, and declassified in 1991. The focus of this document is not that "overpopulation" prohibits economic growth in the Third World, which is the argument stated for public consumption. NSSM 200 directly states that continued population growth in "less developed countries" might lead to the *increase* of the economic, political, and military power of these countries, at the expense of the power of the Anglo-Americans! Concern is also voiced that population reduction will help the United States to continue its access to strategic minerals in the developing sector.

   NSSM 200 lists 13 "key countries" as special targets for population decline: India, Bangladesh, Pakistan, Nigeria, Mexico, Indonesia, Brazil, the Philippines, Thailand, Egypt, Turkey, Ethiopia, and Colombia. Mass sterilization, abortion, and "family planning" are among the techniques called for to undermine the growth of these states.

   More details on NSSM 200 can be found in "U.S. Declassifies Its Depopulation Policy," by Joseph Brewda, *21st Century*, Summer 1991, p. 10.

2001 INDEX

21st CENTURY SCIENCE & TECHNOLOGY

Volume 14

AUTHOR INDEX

SUBJECT INDEX

Agriculture

Astronomy and Astrophysics

Biography and Obituary

Biology

Development and Population Policy

Earth Science

Engineering and Cybernetics

Environment and Environmentalism

Epigraphy

Epistemology and Scientific Method

Fusion

See Nuclear Science.

Geometry

History of Science and Technology

Mathematics

Medicine

Nuclear Science, Nuclear Energy, and Fusion

Pedagogy

Physics

Science and Technology Policy

Space Science, Technology, and Exploration

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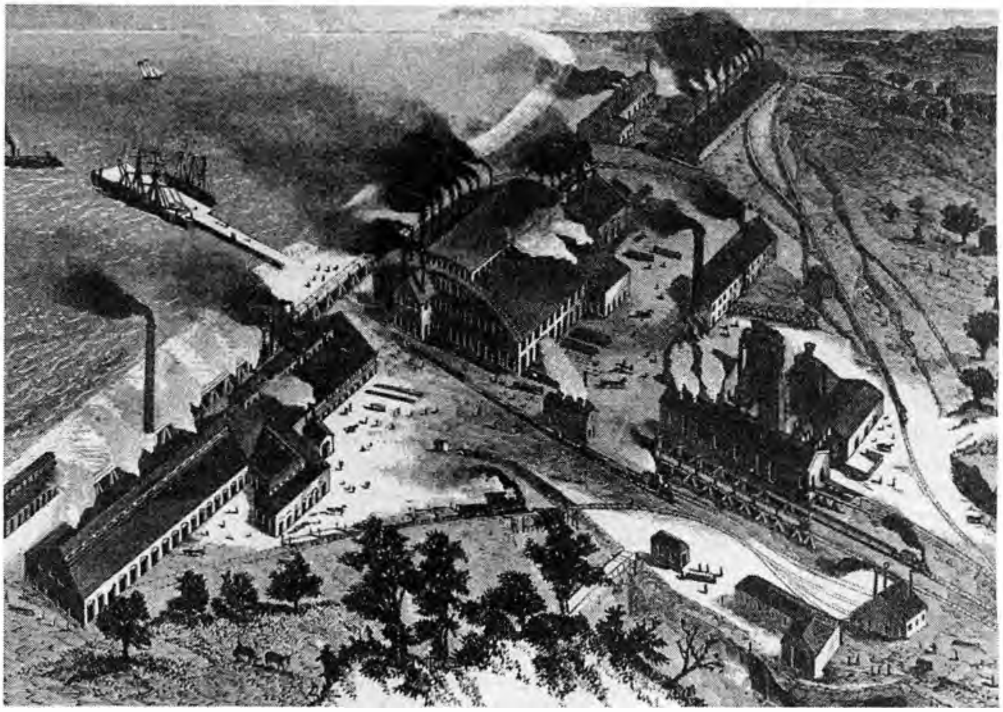
Why There Really Are No Limits to Growth

by Ralf Schauerhammer



The decisive factor for judging the long-term, self-subsisting growth process of the economy is the development of the creative power of labor. This is the cornerstone of the American System of physical economy, which is diametrically opposed to the British "free market" system. Here, an illustration of the Milwaukee Iron Company works in 19th Century America.

In recent months, it has become noticeable that the political endurance of the green zero-growth ideology is disappearing. For example, the greens were not able—except sometimes in attenuated form—to push through internationally their measures against emissions of what they call the "climate poison," carbon dioxide. Such developments have created a political environment in which more and more scientists have gotten up the nerve to come out openly against the untenable theory that the effect of human industry is to bring about a global climate catastrophe.

In Germany, which vaunts itself as an international model of ecological awareness, the Green Party is fighting to stay above 5 percent in the regional elections and the coming federal elections. Meanwhile, in Denmark, a true eco-El Dorado, the prime minister of the new government, the ultra-liberal Fogh Rasmussen, gave "eco-skeptic" Bjorn Lomborg the job of making an in-depth examination of state expenditures for green projects.

Lomborg, a former member of Greenpeace, and Associate Professor of Statistics at Aarhaus University in Denmark, authored a book last year, *The Skeptical Environmentalist,* which rips to pieces—one by one—the hair-raising, lying fairy tales of the environmentalist mafia.[1] And this same "dissident" Lomborg will now preside over when and where the money spigot to the greens is going to be turned off. The pain threshold has been passed, and a wailing and gnashing of teeth are resounding throughout the media and the Internet, hoping for its green echo.

Since the paradigm shift towards a zero-growth society, brought about by the forces behind the Club of Rome—aided and abetted by more than 30 years of conscious lies and propaganda[2]—billions of dollars have been thrown away upon ideologically motivated projects. A correction of the worst excretions of this paradigm shift is long overdue. But what should be the conceptual basis for this overdue correction, for an enduring improvement of the human economy in the biosphere? That is the question.

First, let us ask ourselves, what made it so easy for the Club of Rome to pull off its desired paradigm shift? The trick they pulled in their notorious report, *The Limits to Growth,* was so transparent, that nobody should have fallen for it. The trick consisted of using the word "growth," for something which is, in reality, only "multiplication." It reminds one of the classic example of the lily pond, where the plant population doubles each week. After only one week it is completely full, and—Help! But that is not growth, it is no more than multiplication, which naturally finds its "limits" in the pond's surface area.

True growth includes a quality that transcends mere multiplication. The clearest example is the growth of a human being in the first year after the fertilization of the egg, from which he or she grows. In this process, it is not so much a question of multiplication of cells, but rather permanent differentiation, reorganization, and the development of new organs, which are the substance of true growth. The quality of change of the growth process becomes particularly obvious with the singular event known as birth. Yet, in principle, the same qualitative transformation is true for any growth process that is capable of maintaining itself over any length of time. Naturally, that is especially the case for economic processes.

Why did almost all politicians, economists, and scientists fall for this simple trick? The reason lies in a deeply rooted flaw in the thinking process of the dominant free market economic doctrine, which makes its acolytes blind to the trick. Anyone who thinks that value is created by the parasitical buy-low-and-sell-high principle, does not understand true growth at all.

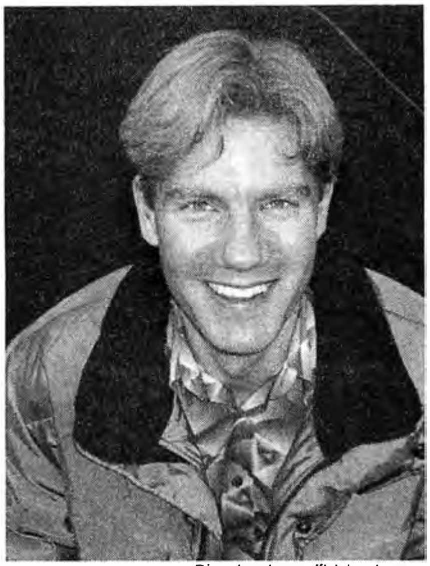
Likewise, anyone who seeks to measure economic growth, as an accountant might, in fixed scalar units, such as tons of production, quantities of money, prices, amounts of energy, and so on, fails to see—just as does the Club of Rome—the decisive factor for judging the long-term, self-subsisting growth process of the economy, namely, the development of the creative power of labor. The essential dynamic of this qualitative development cannot by its very nature be captured by purely statistical methods, nor by so-called "nonlinear" mathematical models. It is this "dogmatic" problem which we will examine more closely here.

Bjorn Lomborg and Julian Simon

In arguing as a "skeptical environmentalist," Bjorn Lomborg avoids everything which is not directly related to statistics. Statistics is his professional field, and here he feels himself relatively secure against the flood of attacks from green quarters. This position is understandable enough, but hardly adequate for making a fundamental change for the better. It is clear—and Lomborg discusses this—that his thinking is strongly influenced by the American economist, Julian Simon.

Julian L. Simon, who died in 1998, asserted—contrary to today's ruling paradigm—that the resources of mankind are not finite, and that, in particular, the "master resource," energy, is adequately available. "At worst, the cost ceiling provided by nuclear power guarantees that the cost of electrical power cannot rise far above present energy costs, political obstacles aside," he writes.[3]

Yet, at the same time, Simon was a representative of the free market economic theory of von Hayek—precisely that theory, which was unable to effectively oppose the Club of Rome's notorious trick. Thus, an examination of Simon's theses promises an interesting insight, into whether or not the new opposition to zero-growth ideology can overcome its blind spot.



Bjorn Lomborg official web page

Skeptical environmentalist Prof. Bjorn Lomborg, whose arguments stay within the realm of statistics.

Julian Simon and Friedrich Hayek

On April 13, 1992, Simon's obituary of Friedrich Hayek, who had died on March 23 of that year, appeared under the title, "The Path of Hayek, Scientist of Freedom, Has Come to an End." Simon wrote:

Julian Simon

Economist Julian Simon, who influenced Lomborg, argues correctly that there are no limits to growth, but locates himself in the "free market" British school, which has failed to effectively oppose the zero-growthers.

"Hayek's great work all flows from the fundamental vision of classical economics and political science, which Hayek terms 'spontaneous order.' This evolutionary principle (originally enunciated in 1705 by Bernard de Mandeville) ascribes the development of society and economy to what Adam Ferguson—colleague of David Hume and Adam Smith—called the 'invisible hand.' Hayek flexibly and pragmatically adapted this principle to various conditions of modern everyday life. . . ."

The admiration was mutual, as attested in two letters of von Hayek, which Simon included in the appendix to his book, *The Ultimate Resource*. In the first letter, dated March 22, 1981, von Hayek writes:

"Dear Professor Simon,

"I have never before written a fan letter to a professional colleague, but to discover that you have in your *Economics of Population Growth* provided the empirical evidence for what with me is the result of a life-time of theoretical speculation, is too exciting an experience not to share it with you. The upshot of my theoretical work has been the conclusion that those traditional rules of conduct (esp. of several property [property held in severalty—exclusively, not jointly]) which led to the greatest increases of the numbers of the groups practicing them leads to their displacing the others—not on 'Darwinian' principles, but because based on the transmission of learned rules—a concept of evolution which is much older than Darwin."

Isn't it touching to see the two men fall joyfully into each other's arms, to celebrate their agreement about the most essential point of economic science? Too bad they both are dead wrong! With "spontaneous order," "invisible hands," and long-wave statistics, the secret of true growth in the economy of humankind in the ecosphere can never be discovered.

Mandeville Vs. Leibniz

In 1705, Mandeville published a cynical satire, called *The Grumbling Hive*—republished in 1714 as *The Fable of the Bees, or Private Vice, Public Virtue*—which Simon emphasizes in his obituary as the "source" of Hayek's and his own most essential concept. This satire became a bestseller and was reprinted five times during Mandeville's lifetime.

Mandeville maintained that Thomas Hobbes's war of all against all, is that which forces man—a "creature of instinct"—into a social order, and this yields Mandeville's essential thesis: that what we call evil in the world, both the moral and the natural, is the great principle which makes us into social beings, the solid basis for life, and the basis for all the industry and occupations of man, without exception; here it is that we have to search for all art and science. As soon as evil should cease to exist, society would have to decay, if not go under completely.[4]

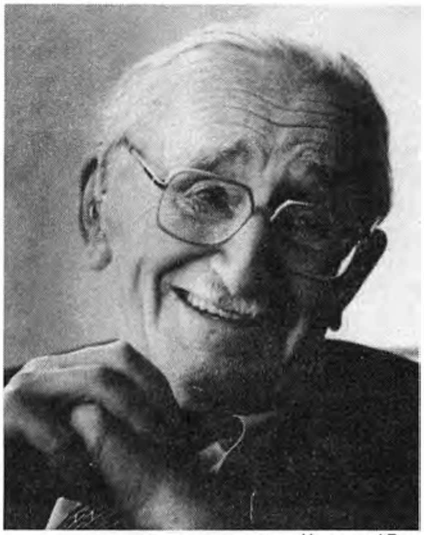
Thus, the "moral" thrust of *The Fable of the Bees,* according to Mandeville, is that "There must be pride, luxury, and deceit for a people to flourish."

Happy the one who has not yet come into contact with the history of free market economic dogma, and would now naturally ask such "naive" questions as: How is it possible that only evil, pride, luxury, and deceit can do something good for society, and, in the second place, how can improvement of society take place by evolution based on "spontaneous ordering"?

Both questions are justified, and easy to answer: both are ideologically based postulates, far removed from actual relations among human beings. There is absolutely no basis for free market economic theory's "optimistic" dogma that "maximal personal gain produces maximum social gain."

It is obvious that, contrary to this dogma, human societies do not arise spontaneously, behind the back of human intellect, so to speak, once people are allowed to indulge their sensual drives, perhaps as the autocatalytic formation of structures occurs in chemical reaction systems, or as in computers which form the images of structures for chaos theoreticians. The improvement of social organization is always conceived of by human beings, and fought for. And often, Friedrich Schiller reminds us, it must be paid for with the "blood of the best and the most noble."

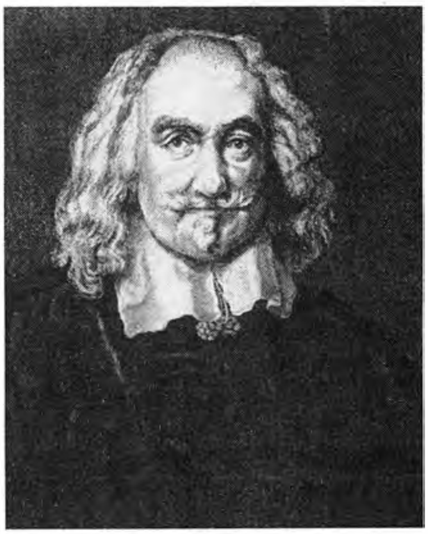
True human freedom is moral action. Moral action does not consist of following a set of virtuous, socially determined rules. The creative man acts morally when he is acting in accordance with his free will. Quite the opposite of the free-marketeer's concept of freedom (which degrades man to a servant of his whims and wishes, and thus must ascribe the existence of society to "invisible" gods, and the development of society to "spontaneous"—that is, "unknowable"—organizational processes), the free moral activity of man brings a joy and a happiness, next to which the most liberal indulgence of the senses pales in comparison.



Harper and Row

Frederich von Hayek, free market guru, based his philosophy on 18th Century Bernard Mandeville's principle that "there must be pride, luxury, and deceit for a people to flourish."

The individual who is moral in this sense, becomes a free citizen of a universe that remains completely closed to Hobbesian thinking and feeling, and becomes a fellow citizen of the "best of all possible worlds." Leibniz did not call it this because everything in the world was as good as it could be,[5] but because man has the freedom to comprehend the world and willfully improve it—that is, as a creature in the image of God, to take part in creation. Schiller expressed this Leibnizian thought, saying, "To be like God is the destiny of man"[6]



Central to the free market school is the view of Thomas Hobbes (1588-1679) of mankind as a war of all against all.

Based on this fundamental standpoint, Leibniz developed the foundations of scientific economics, which explains the creation of value by the increase of labor power and technology—and that without any invisible or spontaneous hands and things.

This economic science was carried over to the United States, the "New World," by Benjamin Franklin, and further developed there. Well into the 19th Century, this was still known as the "American System," the diametric opposite of the British System, the predecessor to what is today euphemistically called "globalization." In the 20th Century, British free trade dogma dominated ever more strongly, and today the only economist who draws explicitly upon the Leibnizian tradition of the American System, is Lyndon H. LaRouche, Jr.

Simon Vs. LaRouche

I now present some excerpts from Julian Simon's "Grand Theory" and go into more detail on the concepts of Lyndon LaRouche. The intention here is not merely to fault the Lomborg and Simon books. Their statistical material is helpful, and should be used to beat the ecomafia over the head, boxing their ears with it until they should no longer dare to spread their shameless lies.

Yet, for us to succeed in turning around the decades-long march down the road to an environmentalist dictatorship, and to solve the current economic problems, will depend entirely upon the degree to which we might rediscover, along with LaRouche, the Leibnizian concepts, apply them, and develop them further.

In Chapter 4 of his book, Simon explains his "Grand Theory" as follows:

"After I investigated case after case of phenomena which the doomsters said were getting worse because of increasing scarcity and population growth, and found instead that they were getting better... I began to wonder whether there is a deep connection, a general theory that embraces all these phenomena. And I believe there is.... In short, humankind has evolved into creators and problem-solvers. Our constructive behavior has counted for more than our using-up and destructive behavior, as seen in our increasing length of life and richness of consumption. This view of the average human as builder conflicts with the view of the average human as destroyer which underlies the thought of many doomsdayers."

So far, we could not be in greater agreement. The problem with Simon's "Grand Theory" makes its first appearance when he explains how and why humankind is generally capable of creative activity. He writes:

"The sort of analysis suggested by Friedrich Hayek, offers an explanation of the observed long-term trend. Hayek (following upon Hume) urges upon us that humankind has evolved sets of rules and patterns of living which are consistent with survival and growth rather than with decline and extinction, an aspect of the evolutionary selection for survival and growth rather than with decline and extinction, an aspect of the evolutionary selection for survival among past societies....

"What are the key patterns that maintained us and increased our numbers? Certainly the evolved cultural patterns include voluntary exchange between individuals, and the market that humankind has evolved to provide resources in increasing quantities; institutions, such as schools that pass on knowledge; libraries and legends and storytellers that store knowledge; and monasteries and laboratories and R&D departments that produce knowledge....

"But ignorance of these cultural and biological patterns is not devastating for us, and such ignorance ought not to be surprising, given the complexity of these patterns and the difficulty of any one person seeing much of any pattern. Belief that our evolved history is, as I suggest, toward being creators rather than destroyers may be strengthened by some evidence that such evolution spontaneously occurs independently within most human groups, as a result of the conditions of natural life that humankind faces."

Is this not remarkable? Simon emphasizes the development of mankind through and for creativity, but when he has to explain what this means, and in which way it is done, he insists on putting man's conscious creativity in parentheses, and relegating it to a "spontaneous" evolutionary process, which the "individual" does not need to be able to recognize, nor is able to recognize, because of its "complexity."

Such contradiction is absolutely not there in the work of LaRouche. For him, the case is just as simple as it, in fact, is. To the degree that the individuals in society, embody and bring into action their typically human creative capability, and consciously transform their technology and culture, their relative population density increases—a prerequisite for the long-term survival of society. LaRouche states this as follows:

"... Reduced to essentials of principle, all validatable discoveries of universal physical principle, occur in the same general form. (1) The use of experimental methods to generate an ontological paradox in an existing equivalent, or analog of a mathematical physics; (2) The generation of a solution, in the form of a newly discovered, or rediscovered technology, or universal principle, from within the sovereign cognitive capabilities of an individual mind; (3) The replication of the original experiment and act of discovery within the sovereign cognitive powers of another individual. (4) The sharing of this experience, in a sufficiently broad way, within a society, to permit the discovered principle to become a subject of the cooperative practice needed to bring the use of the principle to fruition. That, in the simplest possible way, is what should be understood as the act of discovery and social integration of a validatable universal physical principle.

"This method is the foundation for the Classical humanist mode in education, including one's own self-education. In the process of developing mankind's increasing mastery of the universe, there is a certain ordering in the determination of which discovery must tend to occur first, and as second which is likely to occur only in the changed environment brought into existence by the prior discovery. Since the increase of mankind's potential relative population-density, as measured per-capita, per square kilometer, and in terms of demographic characteristics of populations, is the result of man's increasing mastery of the universe through the application of valid discoveries of principle, the following must be said of the notion of time."[7]

This difference between Simon and LaRouche in the creative role of the sovereign individual, is not something minor. It is of decisive political significance, for from LaRouche's standpoint, what follows is that the individual must orient himself to take that political action which will lead to the betterment of society through individual action.

Simon's "spontaneous" mechanism, which acts largely behind the backs of those involved, negates precisely individual responsibility, and, true to the doctrine of Mandeville, from the evil individual comes—wonderfully—economic progress. Politically, LaRouche's appraisal is the foundation for a necessarily representative republican society, while Simon's is very well accepted in an aristocratic system, or a plutocracy in democratic disguise, such as the United States of recent years.

Anti-Entropy Vs. Evolution

Simon makes his "Grand Theory" more profound through considerations taken from physics, entering into the problem of "entropy and limits." It is useful for us to also follow him onto this terrain, since it is to be suspected that here too, we will find again, in a different form, the same problem that we just discussed above. Simon declares:

"The Second Law of Thermodynamics asserts that in a closed system (please note those crucial two words) the random disorder of energy-charged particles must increase over time. The faster that the particles move ... the faster the movement away from order toward disorder.... The doomsdayers extrapolate from this simple idea the belief that the more fuel that humans use in current decades, the sooner our species must come to an end or lack of energy to maintain a patterned existence.... This vision is set forth well by the noted mathematician Norbert Wiener, who at last viewed the grim future with an attitude of Whitmanesque nobility rather than panic...."

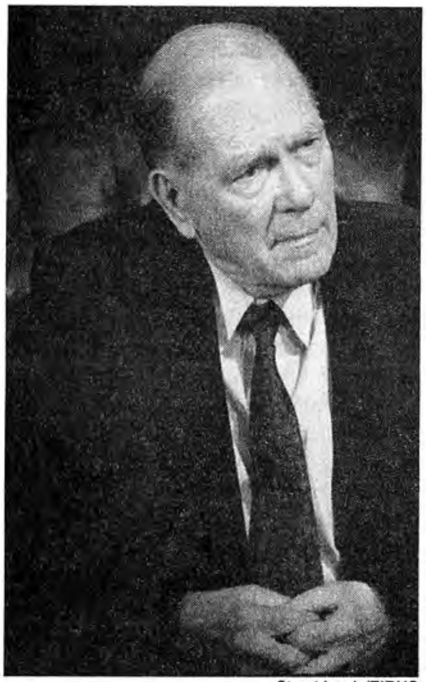
And this is how Simon proposes to solve the problem:

"But whereas the Second Law implies decreasing order, from the point of view of human beings all our observations record a long-term increase rather than decrease in disorder, no matter what quantities we look at. The increase in complexity of living things throughout geological time, and of human society throughout history, are the most important examples, of course. Biologically—as is suggested by the word 'evolution'—the Earth has changed from a smaller number of species of simple creatures toward a larger number of complex and ordered creatures. Geologically, the activities of human beings have resulted in a greater heaping up of particular materials in concentrated piles, e.g., the gold in Fort Knox and in gold jewelry compared to the gold in streams, or the steel in buildings and junk piles compared to the iron and other ores in the ground.... All this suggests more rather than less order in the human environment with the passage of time, and hence contradicts theories of increasing entropy.... The concept of entropy simply doesn't matter for human well-being. Our earthly island of order can grow indefinitely within the universal sea of chaos. Life could even spread from Earth to other planets, other galaxies, etc. incorporating an increasing portion of the universe's matter and energy. What happens at the end of time is anybody's guess: the universe may or may not be bounded. Who cares?"

Just at the decisive moment, Simon throws in the towel, although he is completely right when he reproves the doomsdayers, saying that they are extending, in an illegitimate manner, the validity of the law of entropy. Also, his pointing to anti-entropic evolution in living nature and human society is right on the mark.

But where is the connection? Simon's "Who cares?" is not going to convince any doomsdayer. They will just agree! But this real paradox cannot be pushed off to the "end of time." It is active at each moment, because one must proceed from the standpoint that the universe is intelligible in a coherent manner. Each person strives for such coherent explanation; we can all lay claim to it; without it, there is no science.

Simon fails to reach a level where he might have fruitful discussion with the doomsdayers. The more he urges that development is evolutionary, when actually it must be grasped from the human principle of anti-entropy, the more his opponents will stiffen themselves in the universal validity of the law of entropy, down into the microscopic domain. And who could blame them?



Stuart Lewis/EIRNS

Lyndon H. LaRouche, Jr., today the only economist who represents the Leibnizian tradition of the American System of economics.

The service performed by Lyndon LaRouche is to have rediscovered the school of mathematical physics that runs from Leibniz, through the Göttingen school of Abraham Kästner, through Carl Friedrich Gauss, Bernard Riemann, and Georg Cantor, providing thus the spiritual weapons with which these universally operative principles can be explained.

LaRouche's work is coherent with the fact that he did not nonchalantly dismiss Norbert Wiener's entropic nonsense, as Simon did, but passionately addressed and solved the problem decades ago. Because this cannot be explained in a few words, I refer you to LaRouche's relevant writings,[8] and sketch here only the most general form of the solution.

In the universe, three fundamentally different principles are manifest: first, dead matter, such as for example, described by the law of entropy; second, living matter, which is characterized by anti-entropy; and third, the principle of reason, which is manifested by man's activity. All three universal principles work in the same universe, but not in the same way. This unequal and combined operation cannot be understood within the framework of causal reciprocal action in Euclidean space, but demands the concept of the multiply connected Riemannian manifold.

Perhaps the following simile can provide an idea of this. Imagine a phase space, in which the principle of dead matter works as a kind of funnel, in which a ball bearing runs an elliptical path. The living principle is active in this process, not by working upon the ball directly, but rather, with a very weak force, deforming the boundary conditions of the funnel. By this means, in spite of its weakness, the living principle can bring about qualitative changes, for example, in that it changes the funnel enough, that the "non-living" ellipse suddenly becomes a parabola or a hyperbola.

This double process, which again should be thought of as a single process, in turn has working upon it in a similar manner, the principle of human reason, creating a higher quality of singularities.

The most essential point here is that LaRouche can describe a coherent anti-entropic process that can give a coherent explanation of entropy, not-entropy (called evolution by Simon), and the effective power of human reason in the universe.

It will not have escaped the observant reader, why LaRouche's solution has remained hidden to Simon. The Mandeville-Hayek dogma of "spontaneous" self-organization denies human reason as an actively working force in the universe. Admittedly, it can describe the effects of reason after the fact, but only through a *deus ex machina,* and not in the coherent universal connectedness in which this universal principle manifests itself.

The steepest part of the road is now behind us; the two points still to follow, lead us by an easier path to the goal, but are no less important, because they lead us to the question of why all of this is of such great political significance.

Julian Simon Vs. Julian Simon

When someone like Simon treats a fundamental question with such flimsy arguments, it will take revenge on him in the most unexpected places. One of these, which is of great import for Simon's argument against the doomsdayers, is to be found in his Chapter 26, with the interesting title, "The Effect of Population upon Technology and Productivity."

Simon begins quite correctly:

"The most important economic effect

of population size and growth is the contribution of additional people to our stock of useful knowledge. And this contribution is great enough in the long run to overcome all the costs of population growth. This is a strong statement, but the evidence for it seems very strong. Many who depreciate the potential contribution of knowledge of additional people, and who would halt population growth, also make little allowance for mind-boggling discoveries yet to be made. They assume that what we now believe is impossible, will always be so...."

So far so good. But shortly thereafter, Simon writes:

"This does not imply that a higher standard of living requires additional discoveries.... We now have on our hands the knowledge to provide energy at constant or declining costs forever, and the knowledge to produce food in almost inexhaustible quantities. All other natural resources become less important and a smaller part of the economy with every passing decade. But additional discoveries can certainly be welcome, if only because of the excitement of scientific adventure."

www.arttoday.com

Rev. Thomas Malthus (1766-1834), in his 1798 Essay on the Principle of Population, *argues against the free development of the new American Republic and everything it stands for. Malthus proposed: "All children who are born, beyond what would be required to keep up the population to a desired level, must necessarily perish, unless room be made for them by the death of grown persons.... We should facilitate, instead of foolishly and vainly endeavoring to impede the operations of nature in producing this mortality...."*

Here Simon contradicts himself, and just precisely at the core of his own "Grand Theory." Again and again he has said, and rightly so, that the "cause of new discoveries, or the cause of applying ideas that were discovered earlier, is the 'shortage' of resources."[9] And now he explains that this process has ended. We have reached the point that man is "invented out." From now on, we can engage in science for entertainment, but it is no longer really necessary for our existence. And that, in spite of the fact that it is invention that lays the basis for the existence and growth of mankind?

With this capital contradiction comes the revenge of Simon's cavalier "Who cares?" regarding the entropic principle in the abiotic world, and his concomitant refusal to understand the effective power of human reason in the universe. It is quite clear that the doomsdayers, even if they might only confusedly perceive what is really at stake here, will use the leverage they get from this contradiction, in order to destroy Simon's argument from within.

Malthus Vs. Franklin

I must address another capital fault in Julian Simon's book, an error that I can only explain to myself on the basis that Simon must have had strong prejudices against the intellectual tradition of the American System of economics, and in consequence, against LaRouche, whom he never mentions.

In Chapter 24, Simon correctly attacks the lily-pond example mentioned at the beginning, but then he writes the following nonsense about Benjamin Franklin:

"It is interesting that a similar analogy was suggested by Benjamin Franklin two centuries ago. In Malthus's words, 'It is observed by Dr. Franklin, that there is no bound to the prolific nature of plants or animals, but what is made by their crowding and interfering with each others' means of subsistence....' This is incontrovertibly true.... In plants and animals the view of the subject is simple. They are all impelled by a powerful instinct to increase of their species and this instinct is interrupted by no reasoning or doubts about providing for their offspring... the superabundant effects are repressed afterwards by want of room and nourishment... and among animals, by their becoming the prey of each other.

"Perhaps the most nightmarish of the biological analogies came from Alan Gregg, the former director of the Rockefeller Foundation's Medical Division: 'There is an alarming parallel between the growth of a cancer in the body of an organism and the growth of human population in the earth's ecological economy....'

Library of Congress

Benjamin Franklin staunchly supported the Leibnizian view on the development of labor power—the American System of economics. Yet, Julian Simon fraudulently attributes Malthus's views on population to Franklin.

"But we must recognize what Malthus eventually came to recognize. After he published the short simplistic theory in the first edition of his *Essay on Population,* he took the time to consider the facts as well as the theory. He then concluded that human beings are very different from flies and rats."

This passage contains a howling lie and a malevolent denigration of Benjamin Franklin, which could not but be deliberate on Simon's part. Simon asserts not that Malthus, but Franklin, equates human population growth with that of the animals. For "proof" he cites not Franklin, but a quote from Malthus about Franklin.

Reading Franklin's text of 1751 directly, leads to quite other conclusions. But even a close reading of the text cited by Malthus, shows that Franklin absolutely did not equate the multiplication of animals and man. This equivalence alleged by Simon, is not to be found in the words of Franklin, but rather in a modern passage from Gregg, which Simon places directly after the Malthus-Franklin quote, in order to give the impression that this was also Franklin's opinion. Such a juxtaposition of quotes is counterfeiting of the worst sort.

The level of fraud carried out by Simon becomes still clearer if one reads the cited writing of Franklin in its historical context, and then compares it with how and why Malthus saw himself obliged, at the end of the 18th Century, to publish in great haste, a simplistic essay on zero growth.

When Franklin wrote his *Observations* in 1751, which are quoted a half century later by Malthus, he was not thinking of revolution and separation from England, but he offers practical advice to both England and the American colonies, on how to improve and expand the economies of both.[10] He foresaw a strong growth in the population of the American colonies, because there land is so cheap and would remain so, so that each working man could get cheap land in order to nourish his family and the family of his children.

Franklin said that labor power would be expensive in America compared to Britain, because in America everyone could easily be on his own, and would rather produce independently than work for low wages. Moreover, he said, slave labor in America could not pay off within such a framework.

Finally, Franklin underscores the diametric opposite of the Malthusian premise, in his assertion that a great increase in offspring is not always based upon natural fertility, but upon education in diligence, through which the children are put into the situation of having a better income.

Franklin thus recognizes the significance of the development of labor power for population growth. Malthus, on the other hand, writes the exact opposite, in his *Essay on Population.* A few pages after the Franklin quote brought up by Simon, Malthus writes, "The human race will be constantly endeavoring to increase beyond the means of subsistence."

Let us not forget that Malthus penned his *Essay* only after England had driven the American colonies into the War of Independence, and had lost the war. In this situation, British colonial power did not think Franklin's message—that America would soon have a growing, well-off population—was all that joyful; this was a dangerous threat to the British Empire at the time, all the more because it had to increase the looting of its own population.

The first purpose of Malthus's *Essay,* therefore, is to polemicize against the free development of the Americas,[11] and the second, to propagandize for the repeal of the Poor Laws in England,[12] which argument he bases on a mathematical trick, that "the Poor Laws... themselves create the poor which they are maintaining."

The Rule of the Cuckoo's Egg

Even if one were to accept, that Julian Simon is ignorant of these historical matters, the question remains, why did he decide to make Franklin into a predecessor of Malthus? It is generally known, that Malthus borrowed his Law of Overpopulation, and it is also as clear as daylight, that Malthus lifted the geometric series of population growth from Giammaria Ortes.[13]

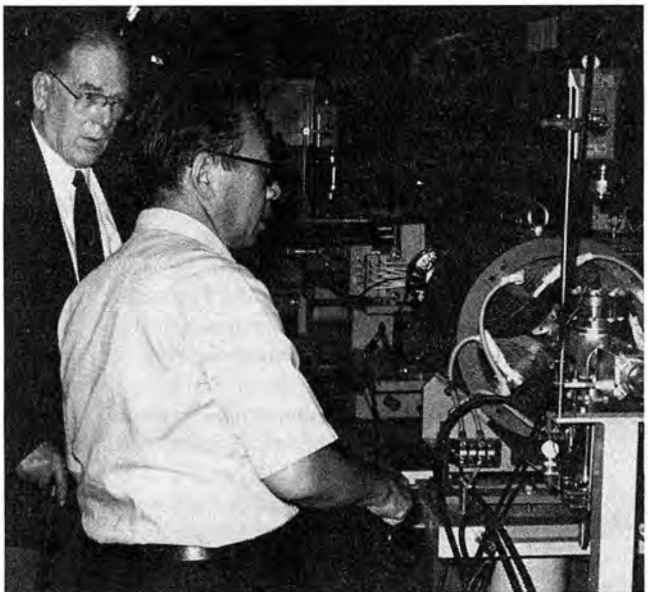
Why is Simon so insistent upon confusing the roles of Benjamin Franklin and Malthus? Why does he wish to attribute to the representative of the American System, the rival principles of the British System?

The quintessence of Simon's "theoretical works" provides an answer. For here we have the assertion:

"... that those traditional rules of conduct (esp. of several property) which led to the greatest increases of the numbers of the groups practicing them leads to their displacing the others—not on 'Darwinian' principles but because based on the transmission of learned rules—a concept of evolution which is much older than Darwin."

If we locate this standpoint within its historic reality, we see the following: On one hand, there is the tradition of the system of physical economy from Leibniz through Franklin into the American System, then through Friedrich List, Witte, and so on, up through LaRouche. On the other hand, there is the system based on greed and parasitism, of Mandeville through Malthus, through the British system of free trade, up through today's globalization, to Hayek and Simon.

History emphasizes again and again, that it is the system of physical economy that creates wealth, by a constant upgrading of labor power, while the free trade system, can only hope to cheaply acquire the wealth created by physical economy. One of the essential rules for the free trade system to survive, is to lay its cuckoo's egg in the nest of physical economy. Thus, when Simon tries to pawn off the Malthusian egg on Benjamin Franklin, he is only conforming to the absolutely essential "practical rules" of the free trade system.


EIRNS

The only true optimism for the future is based on the certainty that mankind can use its creative powers to achieve real growth, by continually improving living standards on Earth—and moving on to colonizing space. Here, LaRouche visits the High Energy Physics Laboratory in Tsukuba (Science) City, Japan.

The Political Reality

Anyone who attempts to use facts from books by Bjorn Lomborg and Julian Simon in the debate with the zero growth ideology, had better be very careful that he is not putting a cuckoo's egg in his own nest. In the present condition of the world economy there is no basis for indulging in the "optimistic" illusion of the free market system of thought that the "invisible hand" will arrange everything for the best.

Today it is anything but doomsday thinking to reject the cheerful prediction of the free market dogma of "always more and always better," no matter how extensive the statistical series that are supposed to prove it. These long statistical series are no more capable of capturing the actual substance or quality of growth than the systems of equations of the computer models that supposedly prove the "limits to growth."

The human population has indeed grown dramatically over the millennia. But this generality must not cause us to forget that many civilizations have collapsed hideously. That there has been overall growth in spite of this, explains nothing of significance. When the development of human civilization is considered with more exactitude, it becomes frighteningly clear that whether the way out of a dark age were to be found, often depended on a mere handful of people.

The achievements of such geniuses are invisible in the long-range statistics, or are attributed to "spontaneous" events. When they fail, however, the statistics suddenly show a dramatic shift. That holds good most especially for our world, in which there is de facto but a single world culture: One cannot now rely, for example, on Arab culture to rescue the substantial corpus of the Greek classical period for the European Renaissance.

That these are no mere abstract considerations, is shown by the writing on the wall in the most recent United Nations population report,[14] in which, after many years of warning of a "population explosion," for the first time there is mention of an imminent "reduction of world population." Several experts even expect an "avalanche-like" collapse of population, which must be taken with utmost seriousness.

It is also necessary to attend to the paradox that popular resistance to the decades-long push of the doomsdayers and zero-growthers is clearly growing, because the economic situation is getting markedly worse. The zero-growth ideology was a phenomenon of prosperity in the industrialized sector, which it was possible to graft onto the poorer countries of this world only forcibly, and with only modest success.

It would be an even greater paradox to expect the "spontaneous" resolution of problems by the "invisible hands" of the free market forces at this precise point in time, in which this globalized free trade system is collapsing. Anyone who does not recognize what it means for President George W. Bush, who took office as a radical free marketeer, to impose protective tariffs to rescue the last remnants of the American steel industry, does not understand what hour the clock has struck. Such a one can take it as guaranteed that his "optimism," based as it is on free market dogma, will soon completely abandon him.

We are entitled to a true optimism for the future by virtue of the certainty that we live in a world which is, in Leibniz's expression, "the best of all possible worlds," in which obviously all is not as it should be, but a world which men and women can continually improve. The scientific basis for this is available to us in the foundations of physical economy.

When we grasp this today, apply it, and make it fruitful in the solution of the world's problems, then we actually will make a better world, with more people, and better nourished and better educated people. We will colonize planets and someday even new galaxies. We will not only do it, we will also know why we are doing it, and we will achieve an ever better understanding of how to drive forward this process of growth in the universe.

Real growth has, in fact, no limits.

Ralf Schauerhammer is an editor of the German-language science magazine Fusion, *a computer specialist, and an organizer with the LaRouche political movement in Germany. He is the co-author of* The Holes in the Ozone Scare: The Scientific Evidence That the Sky Isn't Falling, *published by* 21st Century. *This article was translated from German by Rick Sanders and David Cherry.*

Notes

1. Bjorn Lomborg, *The Skeptical Environmentalist: Measuring the Real State of the World* (New York: Cambridge University Press, 2001)
2. In the *Global 2000* report, drafted under the Carter administration, this was admitted, not without pride.
3. See Chapter 11 in *The Ultimate Resource.*
4. This summary comes from Karl Marx, from his amusing "Digression on Productive Labor."
5. It took the diseased brain of a Voltaire (1694-1778) to concoct the satire, *Candide*, for spreading this kind of lie about Leibniz.
6. In Schiller's dissertation, he explains that "in the image and likeness of God," is not to be understood as a condition, but rather as the process of self-perfection. Schiller's purpose in this work is to demonstrate that in reality, all of man's sensual appetites are ultimately derived from this drive for self-perfection.
7. Lyndon LaRouche, "A Lawless U.S.A. Today: Faith, Hope, and Agape!" *Executive Intelligence Review*, May 13, 2001.
8. A more exact treatment can be found, for example, in the article by LaRouche cited in note 7.
9. In Chapter 3.
10. "Land being thus plenty in America, and so cheap as that a labouring man . . . can in short Time save Money enough to purchase a Piece of new Land for Plantation, whereon he may subside a Family, such are not afraid to marry; for, if they even look far enough forward to consider how their Children, when grown up, are to be provided for, they see that more Land is to be had at rates equally easy.... Labour will never be cheap here, where no Man continues long a Labourer for others, but get a Plantation of his own.... The Labour of Slaves can never be so cheap here as the Labour of working Men in Britain.... The great Increase of Offspring... is not always owing to greater Fecundity of Nature, but... industrious Education; by which the Children are enabled to provide better for themselves."
11. This theme runs like a thread throughout the whole *Essay* of Malthus. In Chapter 14, for example, he writes: "Were I to live a thousand years, and the laws of nature to remain the same, I should little fear, or rather little hope, a contradiction from experience in asserting that no possible sacrifices or exertions of the rich, in a country which had been long inhabited, could for any time place the lower classes of the community in a situation equal, with regard to circumstances, to the situation of the common people about thirty years ago in the northern States of America."

    Or in Chapter 17, the following: "A person who contemplated the happy state of the lower classes of people in America twenty years ago would naturally wish to retain them for ever in that state, and might think, perhaps, that by preventing the introduction of manufactures and luxury he might effect his purpose, but he might as reasonably expect to prevent a wife or mistress from growing old by never exposing her to the sun or air."
12. This is a reference to the milestone Act of Parliament of 1601 under Elizabeth I, "An Act for the Relief of the Poor."
13. Giammaria Ortes, *Riflessione sulla Popolazione delle nazioni per rapporto all'Economia nazionale*, 1790.
14. The United Nations report, *The Future of Fertility in Intermediate-Fertility Countries,* says openly that even in those nations which had high population growth in the middle of the 20th Century, fertility must clearly fall below the rate of 2.1 children per woman, the rate necessary to keep the size of the population constant.

GAUSS'S DECLARATION OF INDEPENDENCE

The Fundamental Theorem of Algebra

by Bruce Director

In September 1798, after three years of self-directed study, the great mathematician Carl Friedrich Gauss, then 21 years old, left Göttingen University without a diploma. He returned to his native city of Brunswick to begin the composition of his *Disquisitiones Arithmeticae,* and, lacking any prospect of employment, hoped to continue receiving his student stipend. After several months of living on credit, word came from the Duke that the stipend would continue, provided Gauss obtained his doctor of philosophy degree—a task Gauss thought a distraction, and wished to postpone.

Nevertheless, he took the opportunity to produce a virtual declaration of independence from the stifling world of deductive mathematics, in the form of a written thesis submitted to the faculty of the University of Helmstedt, on a new proof of the fundamental theorem of algebra. Within months, he was granted his doctorate without even having to appear for oral examination.

Describing his intention to his former classmate, Wolfgang Bolyai, Gauss wrote, "The title [fundamental theorem] indicates quite definitely the purpose of the essay; only about a third of the whole, nevertheless, is used for this purpose; the remainder contains chiefly the history and a critique of works on the same subject by other mathematicians (*viz.* d'Alembert, Bougainville, Euler, de Foncenex, Lagrange, and the Encyclopedists... which latter, however, will probably not be much pleased), besides many and varied comments on the shallowness which is so dominant in our present-day mathematics."

In essence, Gauss was defending, and extending, a principle that goes back to Plato, in which only physical action, not arbitrary assumptions, defines our notion of magnitude. Like Plato, Gauss recognized it were insufficient to simply state his discovery, unless it were combined with a polemical attack on the Aristotelian falsehoods that had become so popular among his contemporaries.

Carl Friedrich Gauss (1777-1855)

Looking back on his dissertation 50 years later, Gauss said: "The demonstration is presented using expressions borrowed from the geometry of position; for in this way, the greatest acuity and simplicity is obtained. Fundamentally, the essential content of the entire argument belongs to a higher domain, independent from space [that is, anti-Euclidean], in which abstract general concepts of magnitudes, are investigated as combinations of magnitudes connected by continuity: a domain, which, at present, is poorly developed, and in which one cannot move without the use of language borrowed from spatial images."

It is my intention to provide a summary sketch of the history of this idea, and Gauss's development of it. It cannot be exhaustive. Rather it seeks to outline the steps which should form the basis for oral pedagogical dialogues, already under way in various locations.[1]

Multiply Extended Magnitude

A physical concept of magnitude was already fully developed by circles associated with Plato, and expressed most explicitly in the *Meno, Theaetetus,* and *Timaeus* dialogues. Plato and his circle demonstrated this concept, pedagogically, through the paradoxes that arise when considering the uniqueness of the five regular solids, and the related problems of doubling a line, square, and cube. As Plato emphasized, each species of action generated a different species of magnitude. He denoted such magnitudes by the Greek term *dynamis,* a term akin to Leibniz's use of the word *Kraft,* translated into English as "power."

That is, a linear magnitude has the "power" to double a line, while only a magnitude of a different species has the "power" to double the square, and a still different species has the "power" to double a cube (see Figures 1a and 1b). In Bernhard Riemann's language, these magnitudes are called, respectively: simply extended, doubly extended, and triply extended. Plato's circle emphasized that magnitudes of lesser extension lacked the capacity to generate magnitudes of higher extension, creating, conceptually, a succession of "higher powers."

Do not think here of the deductive use of the term "dimension." Although a perfectly good word, "dimension" in modern usage too often is associated with the Kantian idea of formal Euclidean space, in which space is considered as a combination of three, independent, simply extended dimensions.

Think, instead, of "physical extension." A line is produced by a physical action of simple extension. A surface may be bounded by lines, but it is not made from lines; rather, a surface is irreducibly doubly extended. Similarly, a volume may be bounded by surfaces, which in turn are bounded by lines, but, it is irreducibly triply extended.

Thus, a unit line, square, or cube, may all be characterized by the number 1, but each 1 is a species of a different power.

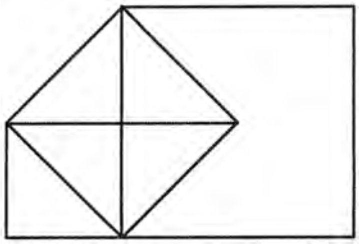


Figure 1(a)
DOUBLING THE SQUARE
The magnitude which has the "power" to produce a square of double area, is the diagonal of the smaller square, and is called "the geometric mean," between the two squares. The magnitude of the length of the diagonal is incommensurable with, and cannot be produced by, the magnitude of the length of the side of the smaller square

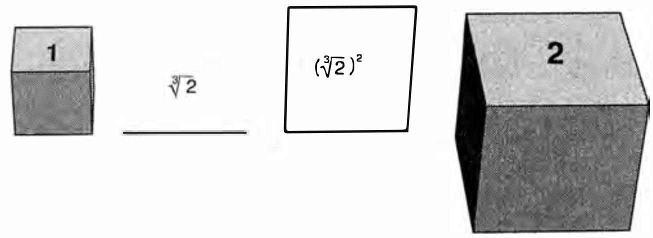


Figure 1(b)
DOUBLING THE CUBE
The magnitude which has the "power" to produce a cube whose volume is double, is different from the magnitude which has the "power" to double a square or a line. It is the smaller of two geometric means between the two cubes. This magnitude is incommensurable with both those lower magnitudes, the square and the line.

Plato's circle also emphasized, that this succession of magnitudes of higher powers, was generated by a succession of different types of action. Specifically, a simply extended magnitude was produced from *linear action,* doubly extended magnitudes from *circular action,* and triply extended magnitudes from *extended circular action,* such as the rotational actions which produce a cone, cylinder, or torus. This is presented, pedagogically, by Plato in the *Meno* dialogue, with respect to doubly extended magnitudes, and in the *Timaeus,* with respect to the uniqueness of the five regular solids, and the problem of doubling the cube. Plato's collaborator, Archytus, demonstrated that the magnitude with which a cube is doubled, is not generated by circular action, but from extended circular action, that is, conic sections.

It fell to Apollonius of Perga (262-200 B.C.) to present a full exposition of the generation of magnitudes of higher powers, in his work on *Conics.* His approach was exhaustively to investigate the generation of doubly and triply extended magnitudes, which he distinguished into plane (circle/line) and solid (ellipse, parabola, hyperbola) loci.

As Abraham Gotthelf Kästner indicates in his *History of Mathematics* (1797), the investigation of the relationships among higher powers, gave rise to what became known by the Arabic word *algebra;* and, from Gottfried Wilhelm Leibniz (1644-1716) on, as *analysis.* Here, the relationship of magnitudes of the second power (squares) and the third power (cubes) were investigated in the form of quadratic and cubic algebraic equations, respectively. Meanwhile, equations of higher than the third degree took on a formal significance, but lacked the physical connection which could be seen in quadratics and cubics.

Girolamo Cardano (1501-1576), and later, Leibniz, showed that there was a "hole" in all forms of algebraic equations, as indicated by the appearance of the square roots of negative numbers, as solutions to such equations. Peering into this "hole," Leibniz recognized that algebra could teach nothing about physics, but, that a general physical principle underlay all algebraic equations, of whatever power.

Writing in about 1675 to Christiaan Huyghens (1629-1695) on the square roots of negative numbers, Leibniz added that he had invented a machine which produced exactly the required action of this general physical principle:

"It seems that after this instrument, there is almost nothing more to be desired for the use which algebra can or will be able to have in mechanics and in practice. It is believable that this was the aim of the geometry of the ancients (at least that of Apollonius) and the purpose of *loci* that he had introduced, because he had recognized that a few lines determine instantly, what long calculations in numbers could achieve only after long work capable of discouraging the most firm."

While finding the physical action that generated a succession of higher powers, Leibniz left open the question of what physical action produced the square roots of negative numbers.

Proof of the Fundamental Theorem

By the time Gauss left Göttingen, he had already developed a concept of the physical reality of the square roots of negative numbers, which he called, *complex numbers.* Adopting the method of Plato's cave metaphor, from *The Republic,* Gauss understood his complex numbers to be shadows reflecting a complex of physical actions (action acting on action). This complex action reflected a power greater than the triply extended action that characterizes the manifold of visible space.

It was Gauss's unique contribution, to devise a metaphor, from which to represent these higher forms of physical action, so those actions could be represented, by their reflections, in the visible domain.

In his 1799 dissertation, Gauss brilliantly chose to develop his metaphor, polemically, on the most vulnerable flank of his opponents' algebraic equations. Like Leibniz, Gauss rejected the deductive approach of investigating algebraic equations on their own terms, insisting that it was physical action that determined the characteristics of the equations.

A simple example will help illustrate the point. Think of the physical meaning of the equation $x^2 = 4$. Obviously, x

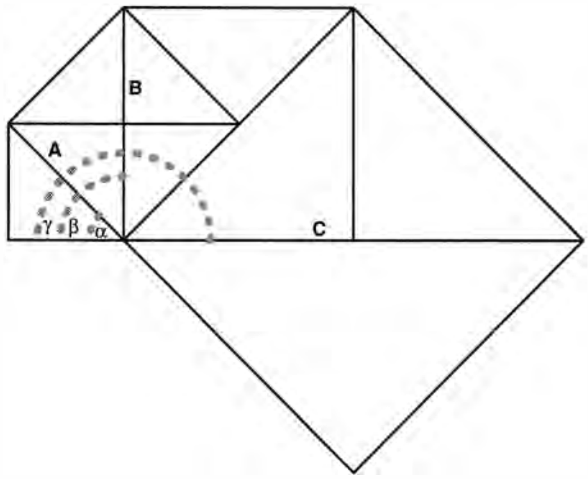


Figure 2
THE PRINCIPLE OF SQUARING
The principle of "squaring" involves doubling the angle of rotation and squaring the length. Angle β is double angle α, and angle γ is double angle β. Also, the length of B is the square of A and the length of C is the square of B.

refers to a side of a square whose area is 4. Thus, 2 is a solution to this equation. Now, think of the physical meaning of the equation $x^2 = -4$. From a formal deductive standpoint, this equation refers to the side of a square whose area is –4. But, how can a square have an area of –4? Formally, the second equation can be solved by introducing the number $2\sqrt{-1}$, or $2i$, which when squared, equals –4. But, the question remains, what is the physical meaning of $\sqrt{-1}$?

One answer is to say that $\sqrt{-1}$ has no physical meaning, and thus the equation $x^2 = -4$ has no solution. To this, Euler and Lagrange added the sophistry, richly ridiculed by Gauss in his dissertation, that the equation $x^2 = -4$ has a solution, but the solution is impossible!

Gauss demonstrated the physical meaning of the $\sqrt{-1}$, not in the visible domain of squares, but in the cognitive domain, of the principle of squaring.

This can be illustrated pedagogically, by drawing a square whose area we'll call 1. Then draw the diagonal of that square, and draw a new square using that diagonal as a side. The area of the new square will be 2. Now, repeat this action, again to generate a square whose area is 4 (Figure 2).

What is the principle of squaring so illustrated? The action that generated the magnitude which produced the square whose area is 2, was a rotation of 45° and an extension of length from 1 to the $\sqrt{-1}$. To produce the square whose area is 4, that rotation of 45 degrees was doubled to 90°, and the extension was squared to become 2. Repeat this process several times, to illustrate that the principle of squaring, can be thought of as the combined physical action, of doubling a rotation and squaring the length. The square root is simply the reverse action. That is, halving the angle of rotation and decreasing the length by the square root.

Now draw a circle and a diameter, and apply this physical action of squaring to every point on the circle. That is,

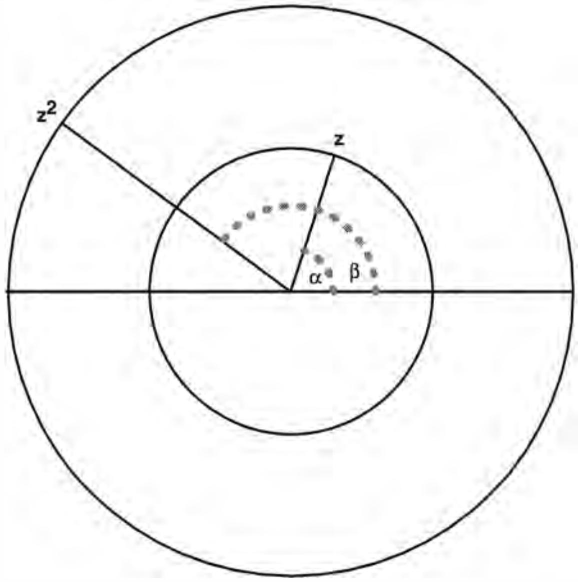


Figure 3
SQUARING A COMPLEX NUMBER
The general principle of "squaring" can be carried out on a circle. The point z^2 is produced from z by doubling the angle α and squaring the distance from the center of the circle to z.

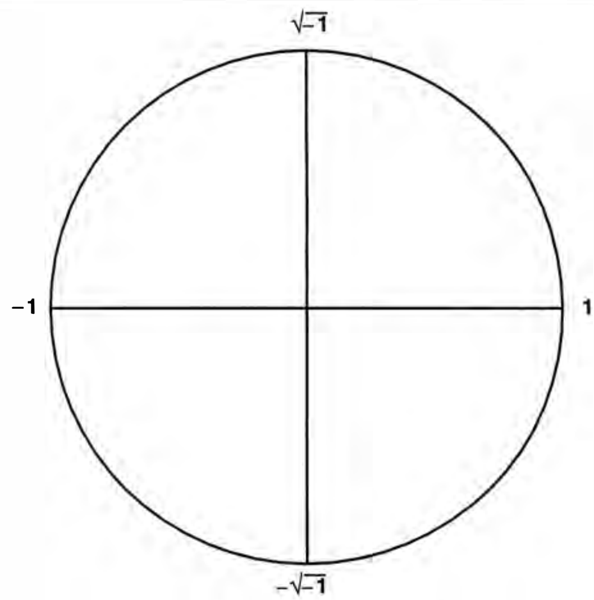


Figure 4
GAUSS'S COMPLEX DOMAIN
Gauss demonstrated that all algebraic powers, of any degree, when projected onto his complex domain, could be represented by an action similar to that of squaring (Figure 3).

take every point on the circumference of the circle. Draw the radius connecting that point to the center of the circle. That radius makes an angle with the diameter you drew. To "square" that point, double the angle between the radius and the diameter, and square the length.

Repeat this action with several points. Soon you will be able to see that the points on the first circle all map to points on another concentric circle, whose radius is the square of the original circle. But, it gets curiouser and curiouser. Since you doubled the angle each time you squared a point, the original circle will map to the "squared" circle twice (Figure 3)!

There is a physical example that illustrates this process. Take a bar magnet and rotate a compass around the magnet. As the compass moves from the North to the South pole of the magnet (180°), the compass needle will make one complete revolution (360°). As it moves from the South pole back to the North, the needle will make another complete revolution. In effect, the bar magnet "squares" the compass.

Gauss associated his complex numbers with this type of compound physical action (rotation combined with extension). He made them visible, metaphorically, as spiral action projected onto a surface. Every point on that surface represents a complex number. Each number denotes a unique combination of rotation and extension. The point of origin of the action ultimately refers to a physical singularity, such as the lowest point of the catenary, or the poles of the rotating Earth, or the center of the bar magnet.

In the above example, the original circle becomes a unit circle in the complex domain. The center of the circle is the origin, denoted by 0, the ends of the diameter are denoted by 1 and –1. The square root of –1 is found by halving the rotation between 1 and –1, and reducing the radius by the square root. Think carefully, and you will see that $\sqrt{-1}$ and $-\sqrt{-1}$ are represented by the points on the circumference which are halfway between 1 and –1 (Figure 4).

Gauss demonstrated that all algebraic powers, of any degree, when projected onto his complex domain, could be represented by an action similar to that just demonstrated for squaring. For example, the action of cubing a complex number is accomplished by tripling the angle of rotation and cubing the length. This maps the original circle three times onto a circle whose radius is the cube of the original circle. The action associated with the bi-quadratic power (fourth degree) involves quadrupling the angle of rotation and squaring the square of the length. This will map the original circle four times onto a circle whose radius is increased by the square of the square, and so forth for the all higher powers.

Thus, even though the manifolds of action associated with these higher powers exist outside the triply extended manifold of visible space, the characteristic of action which produced them, was brought into view, by Gauss, in his complex domain.

Notes

1. This pedagogical exercise is part of an ongoing series on "Riemann for Anti-Dummies," produced for study by members and friends of the International Caucus of Labor Committees. Some have been published in *The New Federalist* newspaper. See also Bruce Director, "The Division of the Circle and Gauss's Concept of the Complex Domain," *21st Century* Winter 2001-2002, p. 20.

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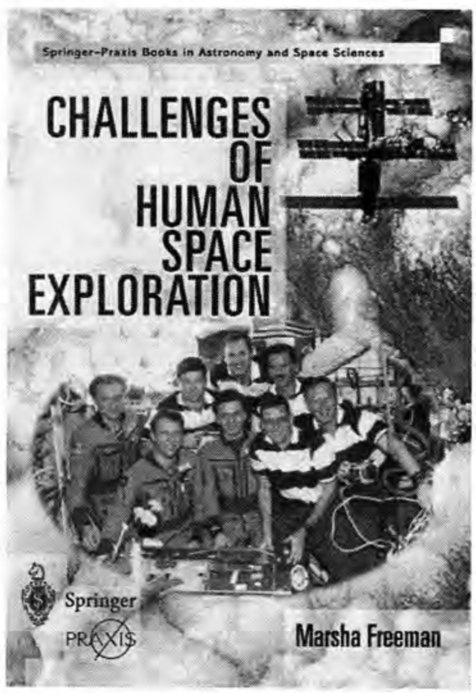

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INTERVIEW WITH WALTER SIMON

General Atomics Reactor in Russia To Burn Weapons Plutonium

Mr. Simon is a nuclear engineer and Senior Vice President for Reactor Projects at General Atomics (GA) in San Diego. He is in charge of the company's joint program with Russia to build a high-temperature gas-cooled nuclear reactor, the GT-MHR, which will use weapons-grade plutonium as fuel.

A graduate of the University of Aachen in Germany, Mr. Simon has worked with General Atomics since 1961, most of that time on the high-temperature gas-cooled reactor. He was interviewed by Managing Editor Marjorie Mazel Hecht at the end of 2001.


Simon: "There is just no way around building these new reactors."

Question: What is the status of the General Atomics project to build the Gas Turbine-Modular Helium Reactor, the GT-MHR, with the Russians?

Our schedule right now is that by early 2002 we will have completed the preliminary design. The Russians have been working on it. There are somewhere between 700 and 800 people in Russia working on this program right now.

Question: Can you describe the reactor design?

The design itself hasn't changed much [see figure, p. 71], but we have much more detail on it than before. It is a high-temperature gas-cooled reactor coupled to a gas turbine. The gas turbine drives the generator, as well as the compressors that circulate the gas. That is basically what we are working on. In addition to that, we need to do fuel development, since we are talking about plutonium fuel.

Question: Because you will be burning weapons plutonium in Russia?

Yes, weapons-grade plutonium. That is the purpose of the project in Russia. They have started to do some testing on reactor components, and we are marching on; the next step is to go into the detailed design, what we call the final design, and then, when that is done, we'll make the plans to start getting the construction work done.

Question: When do you expect a demonstration reactor to be completed?

The goal is still to have the first module on line in 2009.

Question: Is the site in Russia already selected?

Yes, the site that we've discussed with the Russians is Seversk. This is the former Tomsk-7, about 10 or 15 miles out of the city of Tomsk in Siberia. This used to be a closed city, but it is not closed anymore. The Russians still have two plutonium production reactors running there, because they need the power, to heat the city and provide electricity. These reactors will be shut down soon.

Question: So, the GT-MHR, when it is built, will begin burning up the surplus weapons plutonium, of which there is a great deal.

There are many tons of weapons-grade plutonium on both sides—U.S. and Russian. The two governments, actually Presidents Boris Yeltsin and Bill Clinton, each had declared a total of about 34 tons of weapons-grade plutonium as surplus, and now, after the recent discussions that President George Bush had with Russian President Vladimir Putin, they want to reduce the whole weapons inventory further—I haven't seen any specific numbers yet.

Question: It would take a long time for you to get through 34 tons of plutonium fuel.

Yes, the history of that goes way back. The alternative to burning plutonium as fuel, which we continue to work on, is the use of MOX fuel (mixed oxide fuel). The idea was to use MOX fuel in Russian light-water reactors, as well as—they have a fast breeder reactor—doing it with the fast breeder. The number that came out was that the capacity is somewhere between 2 to 2.5 tons per year that could be burned as MOX.

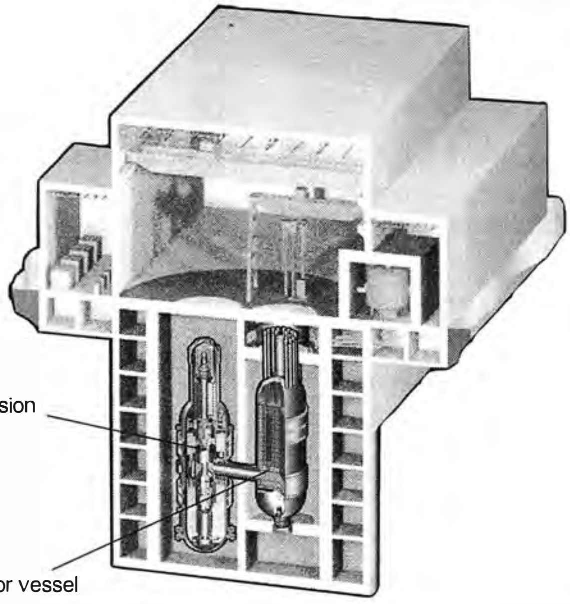
Now, of the material that has been declared surplus, the 34 tons, all will be burnt.

Question: Who is funding this part of the project now?

Our project has one unique characteristic, that in the beginning, GA and the Russian nuclear agency, Minatom, shared the cost. That's how we started.

When the U.S. Congress began to support this program, starting in fiscal year 1999, the Congress required that of the first money it made available (a total of $5 million), $3 million would have to be spent in Russia, but under the condition that the Russians match the amount of U.S. money going into the project.

Well, the Russians have done that, and I'll have to say right now, that this is the only plutonium destruction program with the Russians (and there are several;



A MELTDOWN-PROOF REACTOR:
THE GENERAL ATOMICS GT-MHR

This cutaway view of the current design for a 285 MW-electric power plant, shows the two steel pressure vessels, one for the reactor and the other for the power conversion system. Both are housed below ground, in a concrete building. Above ground are the auxiliary systems for operating the reactor, and the refueling machine.

The GT-MHR produces higher process heat (1,560°F) compared to the 600° limit of conventional water-cooled nuclear reactors, allowing greater electric generating efficiency and a wide range of industrial applications. It uses a direct conversion gas turbine to produce electricity, thus simplifying the reactor system and increasing efficiency.

Source: General Atomics

the light-water reactor program with MOX is still ongoing) where the money is being paid 50-50. The gas-cooled reactor program is, and will continue as, a joint program, which means that for every dollar that the United States puts in, the Russians put in an equal amount. This goes back to the contract we negotiated in 1994-95.

Question: What are the prospects here in the United States for the gas-cooled reactor?

Earlier this year, GA decided that after the electricity problems we had in California, and the energy plan that came out, spearheaded by Vice President Dick Cheney, that we should move forward here with the GT-MHR on the commercial side. First of all, the U.S. Department of Energy started looking at what to do to get nuclear power back on track. Clearly in the long term, and even in the relatively short term, this country is going to need more power, and this means that new power generation sources will have to be built. Even though a lot of coal and gas will have to continue to be burned, the renewables (solar and wind) will not be able to close the gap....

And so, nuclear power has to come back. I'm sure you have seen the numbers. They are talking about 100,000 more megawatts in the next 20 years. And so, we decided that we should also follow a parallel branch here, to what we are doing with the Russians. Even though the Russian design is mainly focussed on the plutonium disposition, in the end, it will be the prototype for a commercial unit. That's the way we look at it.

And we have now started to go in a commercial direction, in parallel to the Russian program.

There will have to be some design changes made relative to the plans we are designing with the Russians. One example is that we would not use plutonium, particularly not weapons-grade plutonium, as the fuel for commercial U.S. applications. This is the track that we are on now.

We will put together a consortium of companies which, hopefully, will work together and modify the design as may be necessary. The plan is really now to march on toward a commercial unit.

We formed a utility advisory committee, led by Entergy, and including Omaha Public Power District, Nuclear Management Corp., Dominion, PSEG, and Constellation. We have several additional companies that have joined, but which have not yet been announced.

The bottom line of all this is that the Utility Advisory Committee represents about 35 percent of the U.S. nuclear-generating capacity. These people are active. These people are in Washington, D.C., fighting for the gas reactor, together with us, or by themselves. It is quite clear that Entergy, for instance, is very interested in getting the gas-cooled reactor moving.

Question: Is the plan that you would move forward here in parallel, and perhaps have another prototype built in the United States?

Yes, in the end we will have to have a prototype in the U.S. However, the prototype we are talking about for the U.S. is about a year or so behind the Russian plan. We would go ahead and build the Russian plant, and then, after that, we would start construction on a U.S. plant.

There are certain things that we would just take over and utilize. For example, the fuel element here would be loaded with enriched uranium rather than with plutonium. And there will be a few other things that will have to be modified....

Secondly, of course, we'll have to start talking with the Nuclear Regulatory Commission (NRC).

Question: Have you begun to do this?

We had our kickoff meeting in December 2001 in Washington; it's what we call the pre-application kickoff meeting, the first dialogue with the NRC to get this whole thing moving.

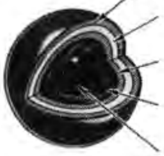
Question: The pebble bed modular reactor [PBMR] design has already been brought before the NRC by Exelon, which is working with the South Africans, and it seems to me, just from

observing from the outside, that the reaction on the part of the NRC is favorable to these new reactors.

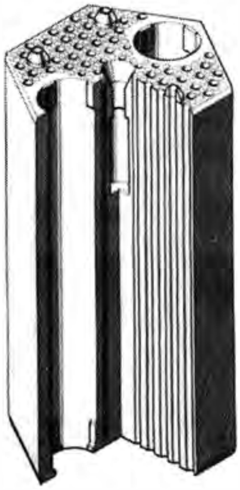
Fundamentally, I agree with you. These are different types of reactors—the PBMR and GT-MHR. They are quite different from the traditional light-water reactors. I can only go back—and I'm putting a little bit of caution in here—in the sense that we had been dealing with the NRC some years ago on the early modular HTGR [High-Temperature Gas-Cooled Reactor], and we had submitted a preliminary safety information document on the design, and we asked for a safety evaluation report and we got all that.

But when the NRC came down in the end, there were maybe something like 10 items or so on the table that would apply for both the conventional light-water reactors and the advanced reactors, in which I would count the liquid metal reactor (LMR), which at that time was on the table, and the HTGR. The NRC spent quite a bit of time on these items, but in the end they came out with rulings whereby it turned out that if there was any doubt of how to do something, they always favored the existing methods for light-water reactors. And we were not enthused about that.

These issues will have to be revisited. But I think the attitude of the NRC, in the meantime, really has changed. They recognize that these machines—the GT-MHR and the PBMR—have passive safety characteristics that make these reactors literally meltdown proof, and there are no other reactors that can do that. This is an example of the things that we will have to discuss and work on with the NRC.



Fuel particle



Fuel block

GT-MHR FUEL COMPONENTS

Tiny fuel particles are encased in ceramic spheres, which serve as "containment buildings" for the fission products. The overall reactor design prevents the reactor from ever getting hot enough to split open the tiny ceramic spheres that contain the fuel.

Each fuel pellet is about 0.03 inch in diameter. At the center is a kernel of fissile fuel—uranium oxycarbide. This is coated with a graphite buffer, and is then surrounded by three layers, two of pyrolytic carbon and one of silicon carbide. The fuel particles are mixed with graphite and formed into cylindrical fuel rods about 2 inches long. The fuel rods are then inserted into holes drilled into hexagonal graphite fuel element blocks, which are 14 inches wide and 31 inches long. The fuel blocks, which also have helium coolant channels, are stacked in the reactor core.

Source: General Atomics

Question: These new designs are really a completely new concept, very different from the existing conventional reactors.

That's right. For example, there is the fact that we have in both of these designs only ceramic material for the reactor. This is all material that can tolerate fairly high temperatures. From a safety standpoint, we have chosen our reactors in terms of physical size and physical shape, such that even if you lose all the cooling, you get fuel temperatures which can basically not exceed 1,600°C, and that compares to a fuel particle that can take at least 2,000°C.

So, we have chosen design parameters, from the geometry to the material, in such a fashion, that you may attack the fuel particle's integrity, but you can never destroy it.

Question: So, the fuel particle's coating is an impermeable containment.

That's correct. The coated particles are one of the barriers [to a fuel meltdown], but of course they are the most significant one.

Question: To go back to the NRC—

In December, we had a whole day meeting with the NRC. That's something that the PBMR already has started.

I would say that we have one advantage, and that is, GA had the experience of the Fort St. Vrain HTGR. This nuclear plant operated in Colorado, and had a steam cycle [not a direct conversion gas turbine], and had hexagonal block fuel elements—about 14 inches across the flats and about 70 inches tall. We are going to use the same graphite fuel element configuration for the Russian design as well as the U.S. design. Why? Well, we have irradiated in total about 2,500 fuel elements in this reactor, where we found only two blocks which had a hairline crack, just two webs.

We had a lot of discussion about this with the NRC at that time, but in the end, the NRC accepted that there was no reason for serious concern, that we could continue to operate with the cracked blocks, because the cracks just relieve the stresses. That's what it came down to.

So we are going to use the same fuel elements, the same shape, with the only difference being that in the United States we'll use uranium fuel instead of plutonium.

The other part that we had the NRC look at in the late 1980s and early

1990s, was the large-scale modular gas-cooled reactor, which had the same fuel elements. In the big scheme of things, in terms of design philosophy, as well as the design itself, things haven't changed that much, although there have been changes in details. And so, my point is that the NRC already has familiarity with our kind of reactor design, but in the case of the pebble bed reactor, the NRC has never reviewed a pebble bed design. And so I think they may have to do more things for the NRC.

Question: In general, in terms of the PBMR, your design has an advantage in terms of the power density. Can you say something about that?

Maybe the simplest way to talk about that is historically. The Germans started out with the modular pebble bed design, and there were some very simple rules that they began with. Number one, there should be no control rods in the reactor. This was an experience from the AVR, a smaller research reactor at the Jülich Research Center, and the THTR [Thorium High-Temperature Reactor], a 300-megawatt electric power reactor, both pebble beds. I did not work on them, but I am reasonably familiar with them.

In the larger reactor, to keep the reactor under control, they had to push the control rods into the pile of pebbles, and this actually damaged pebbles, so therefore, they decided that in the next plant they wanted to build, a modular reactor, they didn't want to have any control rods that had to go into the pebble bed. So, that means, basically, that you have to control the reaction with control rods in the reflector [which surrounds the reactor core], which means that you have to control the reaction by its neutron leakage—because you catch the neutrons in the reflector outside the reactor, and if you catch more, they can't come back [to make more fissions]. This is how you deal with the reactivity.

So this is rule number one. To do that, however, you'll find that the size limit is somewhere around 10 feet—3 meters—in diameter for the reactor core.

The next item is the power density. In a graphite reactor core that is 3 meters in diameter, you do not want to exceed the 1,600°C (the limit in case you lose all coolant), and these parameters basically determine the power density in terms of kilowatts per cubic foot, or watts per cubic centimeter, whichever way you want to do it. It turns out that you come up with something that is about 3 watts per cubic centimeter, and so now you have fixed the diameter and you have fixed the power density.

The only way you can make more power is to make the core taller. Typically, if you look at these numbers, they come out between 8 to 10 meters, and so you have a tall, skinny core. Well, we at GA went through this too. And now comes the question of how you choose your parameters, specifically, by the condition of not having control rods in the core, nor exceeding the 1,600°C temperature during an incident where you lose all your coolant, at which point the reactor would shut itself down, all by itself. However, in such an incident, the decay heat will still build up. And that can only be removed by conduction from the inside of the reactor to the reactor vessel surface, and then radiated away from the reactor vessel surface to cooling panels which surround the cavity in which the reactor has been placed.

So, if you look at the PBMR, I think the commercial modular version of the design was somewhere around 10 meters high and 3 meters diameter, and if you multiplied this out and then figured the efficiency to convert the heat to electricity, the design should have come out at around 100 or 110 megawatts power.

Later, the word came out that the South Africans actually went to an annular core. And I have to say, that whether it's a pebble bed or a prismatic block-type core, if you apply these rules that I mentioned, they are equally restrained by the power level. You have exactly the same problem. You can only go to a certain reactor diameter, because that's all you can control. And once you have that, you can only choose the same power density. So, there is literally no difference in the design limitations.

It turned out, that when GA started working on the modular high-temperature reactor, at the suggestion of Congress, we actually started with the pebble bed reactor. However, we realized within the first few months, that from our vantage point in this part of the world, these plants were too small.

Question: Is this back in the early 1980s?

Yes. We got a letter from Congress in 1984 suggesting that we look at reactors that would be much safer. It took us less than a year, before we said that with this small reactor, we will not be competitive against these big 1,000-megawatt light-water reactors. And so we were looking to go to higher power levels.

The first thing we went to was an annular core. The whole trick with the annular core, is that you keep the path short from where the heat is generated to the place where you can radiate the heat off. That is basically the whole idea behind the annular core.

Sometimes people ask, why don't you fill the inside of the annular core with fuel, rather than putting in graphite blocks. Well, if you do that, you would have to reduce the power, for temperature reasons, to the same size that we would have to go to for a much lower power density, and the total power level would be the same as that of a fully loaded pebble bed reactor without an annular core.

In other words, if you make a larger core, and you want to meet the requirements mentioned earlier, you'll get the same power level you would get if you had a smaller core with a higher power density. And in that case, if there was a loss of coolant, the heat would have to go from the center of the core to the outside, and that heat path is much longer. To drive that heat, the temperature in the center will have to meet the 1,600°C criterion, and you don't gain anything. You do gain, however, when you go to an annular core.

Question: Is that because the space between where the heat is produced and where it gets taken off, is very short in the annular core?

That is correct. That's the bottom line of this. And it turns out that if you go to an annular core, in the annulus, where the fission takes place, we now have a power density over 6 watts per cubic centimeter.

Question: So that's twice the power density of the PBMR.

Well, if the PBMR is just a cylinder, that is correct. But the PBMR has also done something here, and has gone to an annular core.

Question: So is their power density now better?

I think that the power density in the PBMR annulus has gone up to about the same level as our design. They are now talking about 120 to 150 MW electric for the small core.

Question: As opposed to their previous 100 to 110 MW electric?

Yes, and this is a 10 to 30 percent increase in power. They basically took that path. Now, I'm really speculating, because I don't know the facts in that detail, but my assumption is that they did this because they wanted to get the cost down; meaning, if you think in terms of dollars per kilowatts, if you have more kilowatts in the denominator, then the cost comes down. And also, of course, the additional power that you get out helps.

Question: So, your design is larger.

Our design has 600 MW thermal, 285 MW electric.

Question: This size, as I understand it, is about the limit of what can be mass produced. For example, if you wanted to turn out several modules in a factory assembly line, if the reactor were much bigger than 285 MW, you couldn't do it.

I think there is only one company in the world that can at this time give you the steel forgings for the flanges, etc., for such a reactor, and that is a Japanese company.

Question: So that's the limitation on size right now.

That's where we are right now. We are up to something that's about 26 feet in diameter, which is not so easily transportable. Theoretically, you could build a 1,000-MW annular core. But then you have other manufacturing and assembly issues that will have to be dealt with.

Question: The United States has completely dismantled any of its capacity to build a large reactor vessel. The same is true for the fusion reactor program. So what we need is a renaissance to get this program off the ground, and not have just one reactor—we're talking about a need for many reactors in the United States.

That's right, and I wouldn't mind having 10, or 15, or 20 under construction at the same time.

Question: I think that's the direction we have to go in. I don't know how familiar you are with the concept of the Eurasian Land-Bridge. This is a development program, a railway-vectored development corridor, for the Eurasian land mass, which stretches from the east coast of China to the west coast of Europe. The design for this was proposed by Lyndon LaRouche, and is now being undertaken by many of the countries involved—China, Russia, Iran, for example. As developed by LaRouche and his wife, the design includes industrial corridors, and the model nuclear plant selected to power those corridors is the HTGR—either the pebble bed or the GT-MHR. The development area is vast enough so that we would need both designs. So we are very interested in getting mass production capabilities for these reactors.

There is room for both of them. And, in the end, the question is really the cost of the electricity that comes out.

Question: I would also look at it another way, not the cost-accounting way: What is the cost of *not* doing this for our society and for the world?

I was rather referring to the stuff that will be built in the end; the machines that will be built will be the ones that produce the lowest-cost electricity.

Question: Yes, but, I also think that in looking at that formulation, one also has to consider what will happen if we don't do this, where the cost will be incalculable if we don't proceed.

Absolutely. We have to proceed. And I think it may take a little bit longer than we would like to see, but in the end, there is just no way around building these new reactors.

South Africa's PBMR Is Moving Ahead

The initial feasibility report for the Pebble Bed Modular Reactor (PBMR), now under development by South Africa's electricity company, Eskom, has been completed, and the detailed feasibility report has been reviewed by the investor groups, and is now before a 14-member panel of international experts appointed by the South African government.

According to PBMR spokesman Tom Ferreira, "The feasibility study has confirmed that there are no unresolvable issues. The investors have indicated that they remain positive about the PBMR's potential and toward the end of the year will make decisions about the way forward for the project."

Ferreira said that "the investors are taking a cautious and prudent approach to satisfy themselves that all the remaining technical and organizational uncertainties surrounding the project are resolved to the appropriate degree, before committing funds to the construction of the first reactor."

PBMR is a 110 megawatt-electric (MW-e) design. This type of pebble bed reactor was developed in Germany, but Eskom has added new technologies, such as the direct-cycle helium turbine, to make the reactor more efficient. Eskom's partners in the PBMR project include South Africa's Industrial Development Corp. and British Nuclear Fuels Ltd.

The next phase of the project is more detailed engineering and planning work. In addition, there will be a round of public meetings on the environmental impact assessment early this year. "It is hoped that the South African government and the shareholders will give the green light for the building of a construction module before the end of 2002," Ferreira said.

Eskom anticipates exporting up to 30 PBMR modules a year once the program for mass production is under way. Because of the economies of mass production of standardized modules, Eskom has estimated a total cost of PBMR-generated electricity at less than 1.6¢ per kilowatt hour. (Now, most U.S. consumers are paying 8¢, or more.)

—Marjorie Mazel Hecht

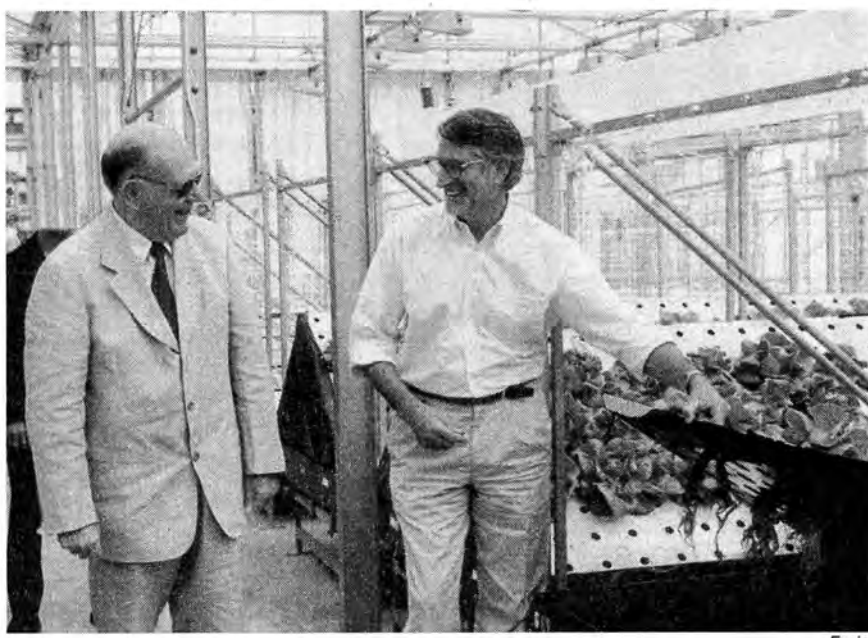
GROWING FOOD IN AIR

A Second-Generation Green Revolution

by Caroline Hartmann and Elisabeth Pascali

For the past 15 years, the Italian company SAID has operated an experimental center for research on new technologies applied to agriculture. Under the leadership of Dr. Giancarlo Costa, this center has developed a new aeroponics process, called the Green Line System, which can be applied on an industrial scale. Aeroponics is the process of growing plants under greenhouse conditions in air, rather than the better known process of hydroponics, where plants are grown in an aqueous solution.

The parent company, SAID, is a small entrepreneurial firm located in Altavilla Vicentina, a suburb of the city of Vicenza in the Veneto region of Italy. SAID (which stands for Special Industrial Applications of Diamonds) is a typical middle-sized firm of this area, owned by its manager, Giannino Bonato. It is a world leader in cutting diamonds for industrial uses, such as cutting granite and ceramics, and in producing diamond tools for machine tools.



Fusion

Dr. Giancarlo Costa (right) discusses aeroponic lettuce growing in the SAID laboratory with Lyndon LaRouche.

SAID has 130 workers and uses very advanced technologies, including a laboratory for materials analysis, which uses a plasma atomic photometer. This revolutionary machine is able to read molecular composition through an atomic beam (a sort of atomic molecular scanner).

Growing in Air

Originally, aeroponic techniques were studied by NASA to solve problems of feeding people employed in space exploration and colonization.

In aeroponics, plants are inserted into support structures with their roots suspended in the air. The roots are regularly sprayed with a nutrient solution, which, in the Green Line System, is recycled through a closed-circuit hydraulic system, in order to minimize water and chemical dispersion.

Although hydroponics has long been developed for areas with little cultivatable land or short growing seasons, aeroponics is potentially a superior growing method all around, for several reasons.

Hydroponics requires a substratum which is often expensive, and which tends to interact with the nutrient solution, absorbing the nutrients and releasing them at a later time, which makes the regulation of feeding difficult. Also, because the roots are constantly submerged, there can be a problem of putrefaction if not enough oxygen reaches them. Finally, hydroponics has not eliminated the possibility of weeds growing together with the crops.

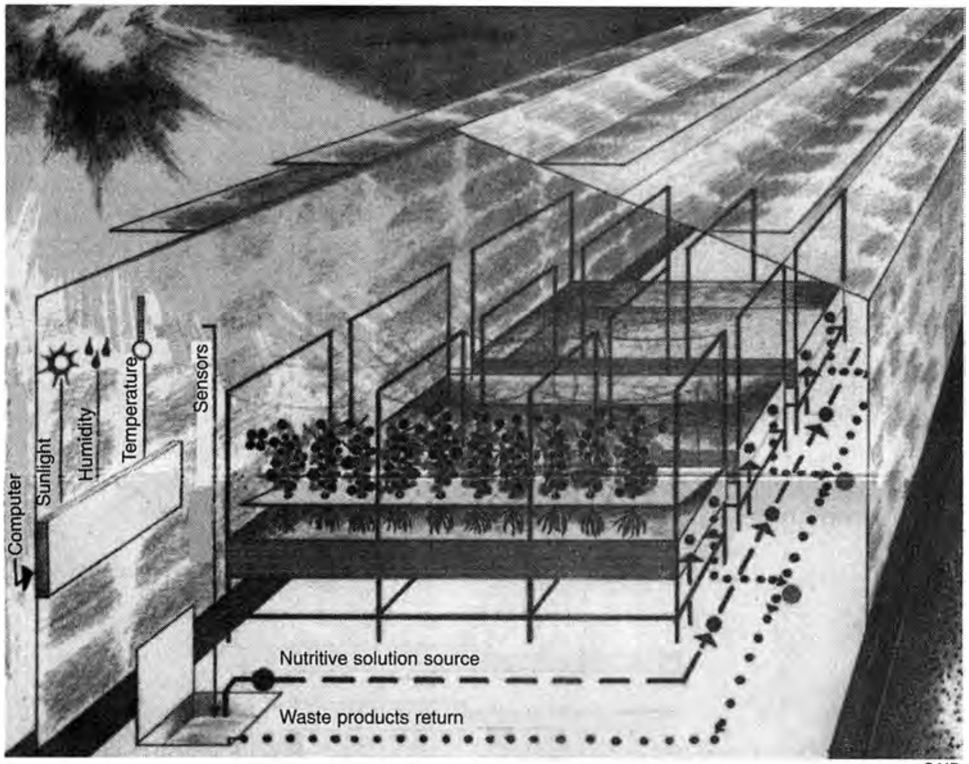
Aeroponics could solve these problems by eliminating the aqueous solution and substrate. It has also been found that, because of the highly controlled growing situation, aeroponic products tend to be richer in nutrients, homogeneous in size, and to ripen more quickly.

When SAID and Dr. Costa began their project, most of the research in aeroponics had been on a strictly academic level. Such "pure research" tended to address one detailed aspect at a time, rather than to focus on the development of an integrated system which could be applied in an efficient way on a mass scale. The SAID project, therefore, set out to take the solutions to problems in the field of aeroponics that had been found from this research, and join it to the industrial processing technology and know-how of their company, to obtain a cost-effective system that could be deployed on a mass scale. About 10 years of study and research were needed to solve the problems that hindered the industrial-scale use of aeroponics, such as lowering the costs of the management of the nutrient solution, and of the electronics applied to plant management.

Their goals for the "ideal aeroponics system" were:

• To lessen the unproductive space in the greenhouse.

Continued on page 82



Schematic of a Green Line aeroponic greenhouse. The central computer monitors the light, temperature, and moisture of the plants, the circulation of the nutritive solution, and the removal of waste.

Out-of-Soil Farming Produces A Superior Product at Less Cost

Dr. Giancarlo Costa, director of the SAID agricultural research center, was interviewed by Giovanni Cilli and Caroline Hartmann in July 2001. Excerpts of that interview appear here, translated from the Italian by Elisabeth Pascali.

Are you the only company in the world that has developed this method?

For the moment, we are unique in possessing a universal solution like the aeroponic invention called the "Green Line System," which is protected globally by patent.

Farming without soil is a necessary change at this point, because of problems related to decreasing soil fertility and the lack of sufficient water or good quality, so it is rather obvious that the world of research and international entrepreneurship should be researching a system that satisfies both requirements.

Where did the idea of aeroponic cultivation originate?

The idea of aeroponics on an industrial scale was born from the needs of greenhouse farmers in the course of the last 50 years. Greenhouse farming in soil had problems with the exhaustion of [nutrients] and mineralization of the soils; hydroponics had problems with the difficult management of the substrates, and the nutritive solutions.

With the Green Line System, the nutritive solution cycle is perfectly managed. The roots are completely in air, and so are not subjected to the influence of any substrate. Thus, the oxygenation is total, permitting total mineral absorption.

What is your relationship with NASA—have you found receptiveness and collaboration? Also, are there companies in the U.S. that work in the aeroponics sector at your same level?

We are aware that NASA has invested many millions of dollars for research in aeroponics systems adapted for use in the orbital stations, but our business does not have any relationship with the American space agency. Some of our researchers have had a great rapport and collaboration with the Russian "City of the Stars" [the Y. Gagarin Training Center for Russian Cosmonauts].

In the United States there are various firms concerned with hydroponics and "out-of-soil" techniques in general, but none has reached our technological level, especially with respect to the completely closed cycles of nutritive solutions.

Which types of vegetables and flowers can be cultivated with the aeroponic method?

The Green Line System allows for the cultivation of almost all of the vegetables and flowers normally raised in greenhouses, and it is completely versatile; that is, one can switch from growing flowers to growing vegetables, and vice versa, with extreme ease. . . .

Can one influence the rate of growth of the plant? Have you encountered a higher rate of growth in these plants as compared to ordinary ones?

At this point it is well known to both researchers and cultivators that have used it, that aeroponics increases both the productive returns per square meter of cultivated surface and the rate of growth of the plants. Because the plants find themselves in the absence of substrate, and with their root apparatus well oxygenated, the mineral absorption is much more rapid, and therefore the metabolic process is accelerated. Plants mature from a week to 15 days sooner with this method than with traditional farming, depending on the type of crop.

How did you resolve the problem of

putrefaction, and of the scum formed in the closed-cycle nutritive solution? You mentioned that this was one of the leading problems that came up in the first phase of experimentation with the aeroponic method.

One of the principal problems in the management of nutritive solutions has been the elimination of the exuded radicals—that is, to put it in simple terms, the toxins emitted from the crop plants during the normal cycle of growth. The solution was possible, thanks to the rapidity of the absorption of the nutritive solution, and to an absence of organic material in the entire [closed nutritive] system that would permit the proliferation of pathogenic agents.

How do vegetables grown with the Green Line System taste?

Obviously, the principal test of products grown with our aeroponic system is made by the consumers, above and beyond the superior organoleptic characteristics that we demonstrate in the laboratory. Well, all of the consumers of aeroponic products, after they have tasted them, find it difficult to return to the traditional ones. They are reminded of the "old tastes" of Grandma.

The tomato, for example, not only has a much stronger characteristic aroma, but is more sweet and has all of those after-tastes that by now have been lost as a result of the inadequate knowledge and management of mineral fertilizers, which has stressed quantity over quality. In aeroponics, both characteristics [quantity and quality] are satisfied, in the right proportion.

What countries are using your system?

We have a number of plants in Spain, Southern Italy, and now the Arab world, where the interest is enormous.

Aeroponics can be adapted for use anywhere in the world. It is time to overcome the common prejudice that it is a technique intended only to save water—even if that remains a priority, and so, most interesting to those countries where water is scarce.

To demonstrate this, look for example at the Ligurian Coast where 50 percent of the greenhouses are abandoned, because, after many years of cultivating flowers in the same terrain, the flowers do not come up anymore because of problems with mineralization and of destruction of the bacteriological flora. Or, look at the tropical zones where the high natural humidity fosters insects that cause huge crop damage. Another big advantage the Green Line System has over traditional cultivation is with regard to the use of additives for the plants' health. We have achieved a 75 percent reduction in the need for such additives, relative to regular production methods. The Green Line product can be defined as "ecologically friendly" and quasi-natural.

Another problem to consider is the quality of life of the agricultural workers. In the Western world, the young find it difficult to enter traditional agriculture because of the lack of dignified conditions. But with the Green Line System, it is like doing clerical work. The worker is on his feet, not bent over; dressed in a white shirt; and in an environment which hovers around 20° C to 25° C (68° F to 77° F) and 50 to 60 percent relative humidity. In sum, ideal conditions for the human body.

"Plants mature from a week to 15 days sooner with this method than with traditional farming, depending on the type of crop."

Furthermore, one gets to work with electronics, agronomy, and chemistry—an occupation which is both fun and rewarding. This is why countries are interested.

Do you also build plants in poor countries?. . .

Our aeroponic system, the Green Line, is particularly adapted to poor countries, where the biggest problems are the lack of water, or the poor quality of the water. With water savings of around 90 percent, we can overcome both of these problems, and activate a start-up of agriculture in the Third World.

Unfortunately, these countries generally don't have the means to provide themselves with such technology, and some financial assistance from the West would be necessary.

In what parts of the world do you expect to see great projects with your technology?

It is our firm conviction that the future of agriculture will be concentrated inside of the solar belt of the planet, which goes from 30 degrees south latitude to 30 degrees north latitude of the Equator. Ideal geo-climatic conditions exist in this band.

Unfortunately, this is also where the poorest countries in the world exist, and where the water problems exist. However, thanks to new technologies, among which aeroponics is included, we can intervene using existing energy (solar) at zero cost to produce an abundance of food. All of this can happen, if the rich countries of the West will decide to invest in these projects within the immediate future, and to resolve the heavy financial crisis that is gripping them.

Since this idea of cultivating vegetables without soil began in the space programs, do you think that aeroponics can have a role in the colonization of the Moon and Mars?

In cases of a long stay in space, the astronauts need to have as close to the same conditions as possible as on Earth, in order not to suffer irreversible physical damage. For proper functioning, the body requires traditional foods (not freeze-dried, or in the form of pills), in order to carry out such regular functions as intestinal peristalsis and the supply of the maximum possible vital energy to the cells.

This can only be obtained by raising fresh vegetables, and this is possible only with the utilization of aeroponic technology, since there is no soil, and the use of water is restricted. Thus, if we want to colonize space by allowing a long stay for some human beings, the only solution is aeroponics.

Do programs already exist to make use of aeroponics in space colonization?

Having collaborated in the past with the Russian Space Program (a few months after the fall of the [Berlin] Wall), I am familiar with the research that is being done in that direction, and, in particular, relative to the creation of a state of gravity, to also overcome the "disorientation" that plants undergo in space. These are problems which are difficult to solve, but which, in part, I have already resolved. However, both the Russians and the Americans are working

Continued on page 82

INTERVIEW WITH ACADEMICIAN NIKOLAI ANFIMOV

Inside Russia's Unique Space Science Institute

Dr. Nikolai A. Anfimov was born on March 29, 1935, in Moscow. He graduated from the Moscow Institute of Physics and Technology in 1958, and became a Research Engineer with the Research Institute of Thermal Processes, now the Keldysh Research Center. A member of the Russian Academy of Sciences, he has been at the Central Research Institute of Machine Building (TsNIIMash) since 1973, and he became its director in February 2000.

Dr. Anfimov is the head of the Coordinating Scientific and Engineering Council of the Russian Aviation and Space Agency, Rosaviakosmos, which oversees the basic and applied research investigations on board the Russian segment of the International Space Station. He has authored and co-authored more than 100 scientific works in aero-gas-dynamics, heat transfer, thermal protection, the ground testing of spacecraft and rockets, and the integrated analysis of prospective space transportation and space systems.

He was interviewed by Associate Editor Marsha Freeman on Oct. 30, 2001, in Washington, D.C.

Question: The history of your Institute is a very long one. It is my understanding that it has been involved in every program since the start of the Soviet missile program.

In recent years, the military and civilian programs have been separate, but we had civilian programs at all times. Before 1992, we had no official space program for civilian purposes, only some scheme, but no long-term public documents. I'd like you to understand that there are two branches of our institute. Originally it was united, joint. It was Research Institute Number 88. Its task was to develop, and to produce the first Soviet long-range ballistic missiles.

In 1956, Sergei Korolov, together with all the designers, and all the factories, separated from the Institute and became independent—Special Design Bureau Number 1. This was the design branch. Today this is the Rocket & Space Corporation Energia, headed by Yuri Semyanov, general designer and president.

The second branch of the Institute was research. From the earliest days, we did research in materials, aerodynamics, the strength of rockets, and so on. After 1956, Research Institute No. 88 became only involved in research. We changed the name to TsNIIMash in 1967, and it became the research institute, which does not design or develop any flight hardware. Of course, we participate in different design and development programs. We really follow all of the rockets, launch vehicles, and spacecraft designed and produced in the Soviet Union and Russia, because we are responsible for scientific investigations, ground testing, expertise at different levels, and so on.

Question: Is it not the case that you also have input into the plans of the Russian Aviation and Space Agency, although you are a research institute? This is very different than in the United States.

Yes, it is very different. In fact, our Institute is very unique. All visitors from the United States and other countries say that there is no analogue in the world, because we combine very different activities and responsibilities. We are responsible for proposals for all the space activities. We prepare the draft of the Russian Federation space program. We receive, of course, proposals from many organizations, but we combine, analyze, and prepare a single draft. After this draft is discussed in the Russian Aviation and Space Agency, there are meetings at different levels, and we present this report to the Agency Board. After this, the space program is signed by the head of the Russian Space Agency, and is presented to the Russian Federation government for approval. Lower-level plans, yearly plans, are also prepared.

Courtesy of Nikolai Anfimov

Nikolai Anfimov: "We are seeing the first positive steps in this direction, of a closer point of view and a mutual understanding."

Question: This means that your space plan is based on technical evaluation and scientific capabilities. In the United States, we start with a political evaluation.

First of all, we make a draft of the space plan with other institutes, because we are obligated to come up with joint programs also for other specialized institutes, so we work together. And the economic institutes are responsible for cost evaluations.

But there are a lot of political aspects. Our Institute and the Russian Aviation and Space Agency (Rosaviakosmos) are involved in discussions with the State Duma [Parliament] in different committees. We talk there very often and I personally have discussions and make some presentations because we consider that different committees in the Duma need to learn more about the problems of space activities—the pluses and minuses of space activity. Rosaviakosmos delegated our Institute to work with the Duma. Of course, officials from Rosaviakosmos are also working there, and their input is the most important, but we assist them.

For example, when leaders of Rosaviakosmos have to give different speeches in the Duma, we prepare preliminary materials. Personally, Mr. Yuri Koptev, the director of Rosaviakosmos, works very hard himself, but we prepare drafts.

Other very important decisions are political. The most striking example, was the situation with the Mir space station. When we decided to stop the flight of the Mir station, there was a political and public storm. Those people who didn't give money for the manned space program, now said, "it is Russia's pride . . . don't kill it; don't make it descend. It is a national treasure." I heard a lot of speeches on our TV, and it was a purely political debate, of course, because last year we had no other choice. From the technical and economic point of view, the Mir station had to descend.

This discussion started three years ago, and if there had been money for the support of the Mir station, it would have been possible [to save it] then. It could have flown several more years. It would have been possible to make repairs; the cosmonauts could have changed some devices. But there was no money, and no repairs, so the Mir station went to its end. It was a political story.

Question: In addition to evaluating specific proposals and developing an overall plan for the space program, how are you involved in space science and technology?

Our second task is to apply our expertise to all the proposals and prospects in Russia for rocket and space technology. Each project from each organization is sent to our Institute and we must evaluate it. It may involve some other organizations that are specialized, for example, in rocket engines, the Keldysh Research Institute, but general conclusions are made by our Institute. Other organizations may sign or not sign, in different cases, but our signature is necessary.

After that, we participate in some design work. There are a lot of science and technology programs, and we are involved with many. Academy institutes are also involved. We are especially involved in ground testing, because we have unique facilities to test real hardware and simulate flight conditions.

An important part of our responsibility is the certification of rocket and space system before the first flight.

Question: So nothing flies unless you certify it?

Yes, we give the final permission to fly. We also collect permissions from leading organizations, for example, Energia Rocket & Space Corporation, for manned flights. After that, we prepare the conclusion. According to Russian law, we need to have permission and certification for only the first flight of space systems. But for the most important missions, such as each manned space flight—including the Soyuz transport vehicle, the unmanned Progress cargo vehicle, some distinct module—we prepare permissions for every article and every flight.

Question: How many people work at the Institute?

Today, about 4,600. Twelve years ago, it was approximately 12,000. We have diminished by two and a half times.

Question: Over the last year, it seems that President Vladimir Putin has put more emphasis on investment in economic infrastructure and rebuilding parts of the Russian economy. There also seems to be a policy to revitalize Russia's scientific manpower. Do you see any change in policy?

There are no big spurts. But really for 10 years we had a diminishing of the space budget. Two or three years ago, the space budget was stabilized. It may have been slightly increased, but there was some inflation which ate the increase. In 2002, we have a draft of the budget, which gives us a more serious increase.

It is necessary for our space industry to cooperate with foreign countries. We have income from commercial contracts, and this enables Russian space enterprises to survive. For example, at the Khrunichev Space Center, they did not do as well as they would like, but they did get good money from launches. Energia Corporation also gets commercial inputs. They do this to compensate for the deficit from government money.

Question: A NASA official said, recently, that in the West, development of a new reusable launch vehicle would cost about $5 billion. No individual company could do this; only the government could do it. But in Russia, the new Angara rocket, and Baikal reusable first

Courtesy of Nikolai Anfimov

Dr. Anfimov (right) and Gen. (ret.) Thomas Stafford in October 2000, signing the protocol for the work of the joint commission to ensure safety for crews on the International Space Station. The signing took place in Rio de Janeiro, during the 51st International Astronautical Congress.

stage are being developed even though the economic situation has been so bad.

The Angara expendable launch vehicle is being developed mostly from commercial money (aside from Angara's rocket engines). Khrunichev Center uses its profits from commercial flights. A very small part is from our government.

Baikal, the reusable fly-back booster, is being developed only with commercial money, without any government support. Khrunichev Center is interested in using new technology to be competitive in the world market. They use their own money for this purpose. Khrunichev Center is a government company. It has no stockholders, so it can invest money in its future advanced projects.

Recently there was a very interesting decision, by Yuri Koptev—by the way, this was published in *Space News*. There was a special decision of Rocket and Space Corporation Energia, Khrunichev, and TsIINMash, and approved by Koptev, for commercial activity on the Russian segment of the International Space Station. The sense of the decision is that commercial activity is done jointly, not done separately by each organization. And the money from commercial activity must be deployed back into the Russian segment of the International Space Station.

Question: Do you have an idea of what percentage of the money Russia will need to meet its responsibilities for the ISS will have to come from commercial activity on the station?

We need approximately a twofold increase for Russia to meet all of its responsibilities. The government money is enough only for the most needed, immediate work, not for next year, and the year after. So the commercial money will have to match the government budget money.

For example, a Soyuz transport vehicle is under production for one year and nine months. To launch Soyuz vehicles in 2003 we now need to begin producing this hardware. Usually, Energia Corporation asks for credit for this purpose. But in the future, they need to pay for this credit.

This is a very delicate question, of course.

Question: When the fight was going on between Russia and the other partners on the ISS about launching space tourist Dennis Tito to the station, most news stories never mentioned that Russia needed the money he was paying for the flight, in order to meet its responsibilities to the partners and the program.

We talked about it, but Western officials didn't understand it; the Congress of the United States . . . Rep. Sensenbrenner, a very "dear friend" of Russia, was permanently against Russian initiatives.

Question: But since the Russian government policy has been changing, it may be more possible to increase cooperation.

Russian government policy was very good all the time, in words, but not in budget payments. There were many holes in our Russian budget.

Question: Your predecessor, Dr. Vladimir Utkin, played an important role in the U.S./Russian cooperation during the Shuttle/Mir program. Do you play an active role in the U.S./Russian cooperation?

Yes. We are continuing this work. There is a very special joint, bilateral commission, for the safety of flights to the International Space Station. Gen. (ret) Tom Stafford is the chairman from the American side, and I am the chairman from the Russian side. We provide a special analysis and prepare a recommendation, for the NASA Administrator and Mr. Koptev, before each new crew flight to the ISS. Mssrs. Goldin [former NASA Administrator] and Koptev approved the work of this joint commission, and because of recent events, it is considered a very important interaction between the United States and Russia on joint space flights.

By the way, before the Tito flight, we worked very hard together to come to a decision on this flight. We signed a joint decision. The American crew departed from Moscow on Saturday at 11 AM, and we signed the joint decision on Saturday at 1 AM, after midnight.

Question: Regarding September 11, it was quite extraordinary that after U.S. nuclear forces were put on alert, the first foreign leader President Bush spoke to was President Putin. In previous times, the Russian military would also be on alert, but President Putin said that the Russian forces would stand down, because he understood the security threat to the United States. It would

NASA

Expedition 4 crew members Daniel Bursch, Yuri Onufrienko, and Carl Walz pose on Dec. 11, 2000, during their four-month stay on the International Space Station. Before the start of each mission, the commission, headed by General Stafford and Dr. Anfimov, must certify the safety of the station.

seem that there are changes in the U.S./Russian relationship, after September 11.

We are seeing the first positive steps in this direction, of a closer point of view, and a mutual understanding. I hope this understanding will be closer. It's very important, from our point of view, that before September 11, there was no understanding from American, and Western organizations, of the events in Chechnya.

They conceived this as a battle of the Chechen people for their independence, but the roots of these two events are the same. Terrorism was financed by the same bin Laden and there are a lot of foreign fighters among the Chechen troops. We see that now in the United States there is a much better understanding of the unity of these two problems.

Of course, there is a big difference. Chechnya is a part of Russia and always will be an area of Russia. For you, bin Laden is far from the United States and you are not fighting on your ground, but in another country. This is the difference. But the roots are similar.

Question: There have been a number of joint military R&D projects, some of which were not being funded adequately in the United States. Are they continuing?

I can't answer your question because our Institute is not involved in military projects with foreign countries. There are other people in the Ministry of Defense who work with foreign companies. We work with the Ministry, for Russian military forces, but not jointly on American military projects. They worked independently from us.

I know the RAMOS [Russian American Observation Satellite] project. It is led by Academician Anatoliy Savin, former head of Cometa, a scientific production organization, which is involved in developing satellites which watch areas of potential missile launches—special early warning spacecraft.

Our Institute is involved only in some scientific projects, such as the investigation of the radiation of rocket plumes, because a launch is detected by the radiation of the plume. This is our speciality—the investigation of physical processes, such as radiation.

Question: One technology now moving into flight testing in the United States is hypersonic technology. What research is being done in Russia in this area?

We cooperate with Americans in scientific conferences in hypersonics. For many years, I was a member of the committee of the American Institute of Aeronautics and Astronautics, which arranges these conferences. I represented Russia there. Now, another man from our Institute is a member of this committee.

At TsNIIMash we have supersonic and hypersonic wind tunnels, a unique piston gas-dynamic facility with multi-cascade compressions (PGU), and high-temperature electric arc facilities. One of our first commercial projects with the United States, six or seven years ago, was with the GASL—General Applied Science Laboratory, under NASA, which is on Long Island in New York. We did special testing in a PGU for a hypersonic vehicle. It was the first testing of a model hypersonic ramjet engine with a supersonic combustion process.

Question: What are the most important projects that the Institute is working on now?

Perhaps our cooperation on future launch vehicles. We are working hard investigating new technologies for future launch vehicles. I can mention also new technologies for small spacecraft, among which are very effective electric thrusters, so-called ALT—anode layer thrusters. By the way, last year the ALT developed and produced at TsNIIMash flew on an American research spacecraft.

Question: Are you looking at reusable or expendable launchers?

We are looking at both. We are looking at the modernization of expendable launch vehicles; new fuels, such as methane and liquid natural gas; and also in the reusable direction. We are responsible for systems analysis and the total program. We invite other organizations to participate.

For example, we always do the work with materials. We are testing samples for vehicle construction and for thermal protection, and construction elements in various test facilities, which simulate flight conditions and the space environmental. We don't develop new materials, but work with other research institutions that develop them.

Question: How are the technical data transferred from your Institute to an organization, such as the Khrunichev Design Bureau?

Khrunichev Center designs vehicles themselves, but they often use our preliminary results to design their vehicles. It was our finding, for example, that it was most important for Russia to have a reusable first stage, for a future Russian reusable launch vehicle. This

Courtesty of Khrunichev Space Center

The new Angara family of launch vehicles is being developed at Khrunichev Space Center, mainly from funds it receives from commercial launches of its Proton rocket.

was the conclusion of our research, over several years. Khrunichev Center is using this idea for designing their Baikal boosters. In addition, they then ordered a lot of different partial investigations and testing from our Institute. They asked for research concerning gas dynamics, acoustics, and so on.

We used their money, among other things, to pay our staff.

Question: What is the advantage of the Baikal, the reusable liquid fly-back booster?

A reusable first stage will have the advantage of a lower total cost. But, more important is the environmental situation. Your launch site is at the ocean, so you have much less of an environmental problem of spent boosters and stages falling down on land.

We have continental cosmodromes. Our first stages cross over the land area of Russia, Kazakhstan, and Turkmenistan. In 1999 we had a lot of problems, because of accidents with two Proton launch vehicles. Kazakhstan forbade launches of Protons from Bailkonur for some period. That is why we are interested in not having the first stage fall down, but fly back to the launch site.

We could use other launch areas, such as Kapustin Yar, on the Volga River near the Caspian Sea, if there were no possibility that the first stage would fall down. If it is a fly-back stage, other launch sites may be used. It is much more flexible.

Question: Do you plan to have launches from Australia?

Some agreements are signed. A new launch vehicle must be developed, the Aurora, which can be considered a modification of the Soyuz launcher. It will have a new central core stage, with NK-33 rocket engines, which were developed and produced in the 1960s-1970s for the Russian Moon rocket, the N-1. Our Institute is involved in some testing, and is providing expertise on this project.

Question: What do you see as the longer-term goal of space exploration?

Anfimov: A manned expedition to Mars is the dream of rocket technology pioneers. Now is the time for conceptual and feasibility studies of such an expedition. Such research is now under investigation in Russia, at the Keldysh Research Center, Energia, TsNIIMash, and other organizations. The main questions under investigation are the mission scenario, power/propulsion complex, and so on.

Today we can forecast manned Mars expeditions in 2015-2025.

Green Revolution

Continued from page 75

- To obtain even and constant lighting (preventing the plants from having to compete for light).
- To allow the same setup to successfully produce many different crops.
- To make the installation and maintenance of the system inexpensive and suitable to various greenhouse and climatic conditions.
- To decrease the amount of chemical waste.
- To create large savings in energy, water, and labor.
- To control the entire climatic and nourishing system through a computerized sensor system.

The resultant product is SAID's Green Line System. Today, SAID has sold and built aeroponics plants in the Canary Islands, southern Spain, Italy's Mezzogiorno region in the south, and the Middle East, and it expects to expand well beyond this.

The Green Line System, according to its developers, makes aeroponics competitive, not only with traditional agriculture, but also with hydroponic agriculture. Green Line aeroponic farming allows productivity increases per square meter which are three times higher than those of traditional farming. Further, the closed-cycle nutrient solution permits 90 percent of the water to be saved, with zero pollution.

Economist Lyndon H. LaRouche, Jr., a member of the scientific advisory board of *21st Century* visited the SAID laboratory in July 2001. In an interview at the time, Mr. LaRouche stressed that firms like SAID are a concrete example of what really creates wealth and profit in the economy: the application of new scientific and technological discoveries to labor productivity, through the development of machine tools, industrial machines, and new design processes.

Interview with Dr. Giancarlo Costa

Continued from page 77

on using aeroponics for space.

We know that you have also developed innovative ideas for combatting cancer. Can you tell us about that?

I think that every individual, besides working and enriching himself, must also give something to humanity, just as humanity gives to the individual. . . . With this logic, I thought of putting at the disposal of humanity, free, my personal research abilities, directed toward the most dreadful evil that afflicts mankind: cancer.

My innovative idea is that the assertion of traditional medicine, that genetic mutations cause cancers, is one of the most colossal lies in existence. Not even 5 percent of cancers are caused by genetic mutations, and in those cases, the patient has been exposed to high doses of radioactivity. But does it seem possible that the "Grand Architect" that has planned the universe and man, has created a structure of DNA—genetic mutations—so fragile as to be able to be modified by pollution, or by an error in nutrition? Traditional medicine now recognizes tumor co-factors, and this consideration alone is sufficient to found research on a completely new basis.

What approach did you adopt?...

I put together some among the most brilliant minds on the planet that were disposed to see this pathology from a completely different angle than that of establishment medicine, and not neglect anything that has been done. Thanks, above all, to aeroponics, we have arrived at the conclusion that cancer manifests itself only when there is an alteration of the acid/base ration in the organism.

This alteration happens as a result of diverse co-factors, such as smoking, pollution, wrong eating, stress, and so on. Obviously, to develop this argument in any detail would require a book-length report, not just a few lines in a magazine. However, the advice that I can give to those sick with tumors is that if they want to heal themselves, the principle requirement is that of alkalizing the body before undertaking any type of therapy.

The Authentic But Not Official Rickover

by Theodore Rockwell

Rickover: The Struggle for Excellence
by Francis Duncan
Annapolis, Md.: Naval Institute Press, 2001
Hardcover, 364 pp. $37.50

Dr. Frank Duncan is very clear that this is not an "official biography." After a decade of interviews and records searching, he will defend its accuracy and completeness. But, he explains, an "official biography" implies that someone has hired a writer to document a pre-determined story, and Duncan is an independent professional.

Professional historians, like practitioners of the world's oldest profession, suffer unfair competition from amateurs. All writers believe they are fully qualified to write history, and they do so shamelessly (this reviewer included). But professional training and long practice in the art make a difference, as Frank Duncan shows us in this biography, the product of a full decade of meticulous chronicling and research.

Much has been written about four-star Admiral Hyman George Rickover, USN. Clay Blair, Jr., wrote *The Atomic Submarine and Admiral Rickover* in 1954. But Blair was a Pentagon correspondent for *Time-Life,* and his story was focussed on the Navy's effort to force Rickover's retirement at age 53. Blair's book was important in bringing Rickover to national attention. But it read like the *Time* cover story that it became.

Norman Polmar and Tom Allen, experienced writers, began their 1982 book, *Rickover: A Biography,* by quoting a note from Rickover's secretary: "Admiral Rickover does not desire to have a book written about him. Therefore, he will not grant the interviews you requested." And so, their 200 interviews did not include many of the key players. Polmar told me that the "unauthorized" aspect of his biography was what made it sell; but it didn't make it authentic.

In 1992, I wrote *The Rickover Effect: How One Man Made a Difference.* Unlike the other authors, I was a player in the events I described. But I am neither a historian nor a professional writer, and my book was more of a memoir than a biography.

The Real Rickover

So now, at long last, we have an authentic biography, the product of an experienced, independent historian, located "on site," in an office near Rickover's, with complete contemporaneous access to the files and records, from 1969 until the Admiral's death in 1986. He continued his writing and research almost to the publication date of this book in November 2001.

The challenge Duncan faced was not a shortage of information, but a need to sort out the facts and the stories from a plethora of anecdotes ranging from improbable but true, to believable but totally fabricated. And among all the stories about events and world figures, he was also trying to bring into focus the real Rickover. For there is, after all, a human person inside and nearly hidden by the icon.

Rickover is widely known as "the father of the nuclear navy." That story has been told in many places, including Duncan's prize-winning 1990 book, *Rickover and the Nuclear Navy: The Discipline of Technology.* But the extent and true nature of Rickover's contribution to the commercial development of nuclear energy is little appreciated, even by those in the field. When President Eisenhower asked Admiral Rickover to build the world's first commercial atomic power station, many believed that he would merely go ahead with his aircraft carrier prototype plant, which had never been approved, and put a civilian label on it. They didn't know Rickover. He didn't do things half way.

Rickover was a strong enforcer of security classification. "Don't help potential enemies copy our best weapons," he said. But when he was tasked to create a civilian plant, he determined to do more than just build a demonstration plant. He would lay a declassified technological foundation for an entire industry. Back in 1947, when he first went to Oak Ridge to learn nuclear technology from the Manhattan atomic bomb project scientists, he started his people collecting and collating all the relevant technical information and data on various aspects of nuclear technology. They got it declassified, and published it in handbooks—nuclear physics, beryllium, radiation shielding, liquid metal technology—13 handbooks in all.

Rickover extended this process in his new civilian capacity and started getting all this new information hammered into the American codes and standards system—boiler and pressure vessel codes, welding standards, and so on. A Civilian Reactors Branch had been set up in the Atomic Energy Commission, to parallel the existing branches covering naval, army, and aircraft systems. Rickover worked with its Director, a lawyer named Hal Price, to ensure that the kind of operator training and monitoring that he used for Navy crews could and would be applied by industry.

Most of that story is not covered in this Rickover biography. Duncan had discussed it in his 1990 book on the technological lessons learned in Rickover's program; he did not need to go back over that material in this biography. But I mention it here so that people

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working today in the commercial aspects of nuclear technology would be reminded to be aware of the source of much of what they take for granted in their daily work.

In today's environment, where textbooks, trained nuclear engineers and scientists, pre-tested computer software for design and operation, and a selection of code-stamped nuclear components such as pumps, valves, instruments and computer codes are all readily available, it is hard to imagine what our world would be like if Rickover had not taken on the chore of seeing that all these things would be there when they were needed. Today we hear cries that there is so much uncertainty, no leadership, and layers of bureaucratic obstacles. How can one hope to make progress? I suggest that you picture as best you can what life would be like if we had yet to develop these many tools and aids that were Rickover's legacy.

For the Record

A reviewer is supposed to find an error to show that he did in fact read the book. I found one, but the author beat me to it. On page 156, discussing Rickover's role in helping the British establish a nuclear submarine program, Duncan writes that the British found Rickover "hard to deal with, hard to predict, and often abrasive, but without him they would never have gotten their first nuclear submarine to sea." "Never, Frank?" I asked Duncan. "That's a long time." But he had already found that error and he was highly upset by it.

"As published, that's a devastating judgment of England's technological capabilities," he told me. "But the manuscript I submitted had two more little words before the period. I said 'in 1963.' I can see how the press's editor might have figured we didn't need that phrase, since I had set the time frame earlier in the paragraph. But look at the difference it makes! All I intended to say was, it would have taken them longer. I'd sure like to straighten out the record on that."

Courtesy of Naval Institute Press

Admiral Rickover, in a rare photograph that shows him with a smile.

Lessons and Inspiration

Now, in that retrospective mode, read this fine biography of Duncan's and see how Rickover faced and overcame many of the same sorts of obstacles we find before us today. There are both lessons and inspiration in these stories. All solutions seem obvious after the fact. And all obstacles look less formidable when you know they have already been overcome. Duncan brings alive again those days when Rickover often said, "There's nothing in the Old or New Testament that says this has to work."

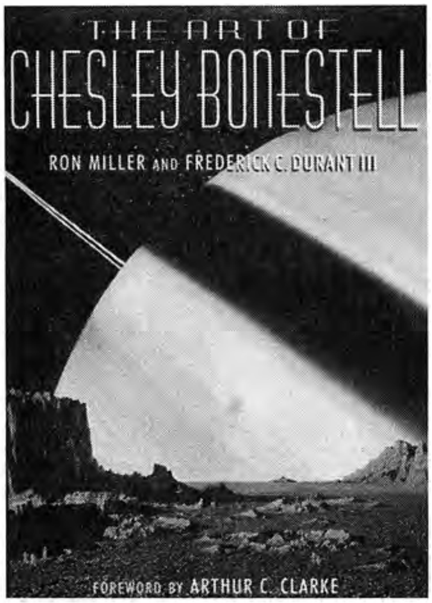
It seems unreal to say it today, but we were not at all sure that the decisions made then would prove to be workable. Nobody assigned Rickover his task, and no one was there to assure that he would get what he needed to do it. I urge you to read this book and regain the spirit of uncertainty and high adventure that once characterized the nuclear enterprise. It will help you put today's obstacles and uncertainties in a new perspective. Because now as always, in the old warrior's phrase, "Fortuna Audaces Juvat" (Fortune favors the bold).

Theodore Rockwell worked for Admiral Rickover in his headquarters 1949-1964, the last 10 years as his Technical Director. He is a founding officer of MPR Associates, Inc., and of Radiation, Science & Health, Inc. A version of this review appeared in Nuclear News, *December 2001.*

The Man Who Inspired the Space Age

by Marsha Freeman

The Art of Chesley Bonestell
by Ron Miller and Frederick C. Durant III
London: Paper Tiger, 2001
Hardcover, 256 pp., $50.00



At the age of 5, Chesley Bonestell began to paint. And, at the age of 10, "he became fascinated with the sight of Venus in the evening and morning skies," the authors of this biography recount. This combination of a talent for painting, and a fascination with astronomy, would later produce the premier artist of the Space Age.

In 1905, at the age of 17, Chesley Bonestell and a friend "caught an early train to San Jose and hiked the twenty-six miles to the summit of Mt. Hamilton and Lick Observatory," Bonestell reports. (He had free passes from the Southern Pacific Railroad, for which he was doing magazine illustrations.)

"That night I saw, for the first time the Moon through the 36-inch refractor, but most impressive and beautiful was Saturn through the 12-inch refractor. As soon as I got home, I painted a picture of Saturn." That painting was lost the following year in the great San Francisco fire, but it started Chesley Bonestell on a more than 50-year career of portraying on a canvas what men could only imagine existed in the universe.

In 1910, Bonestell, while an architecture student at Columbia University in New York, observed Halley's Comet. In 1986, the year he died, Bonestell became one of the handful of people to witness the return of Halley's Comet twice in his lifetime.

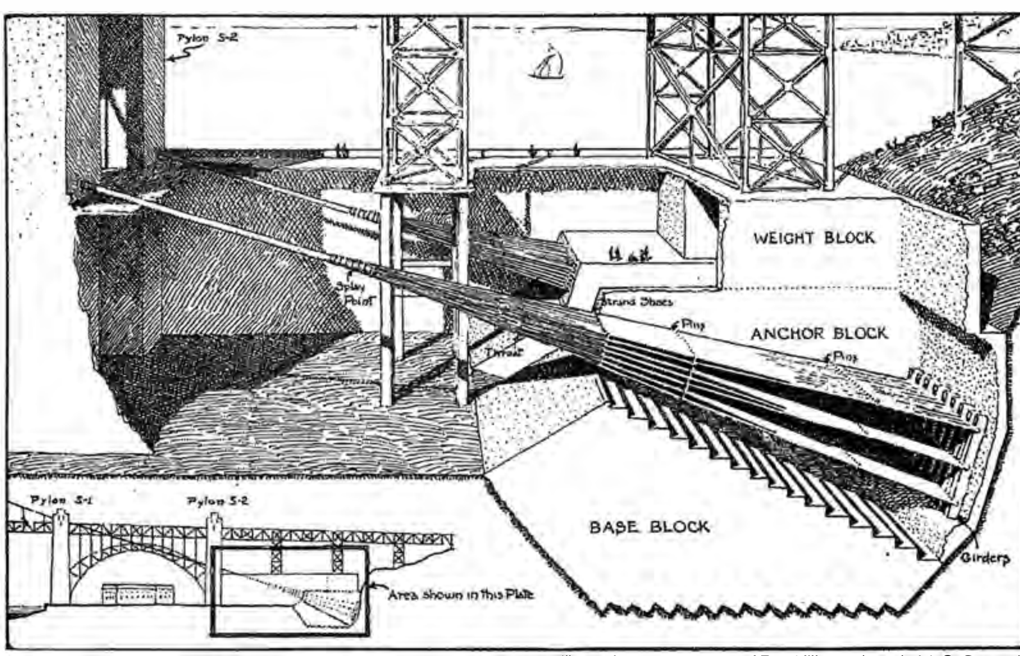
A Love of Great Projects

After studying art and architecture, Chesley Bonestell left Columbia University in 1910 (without earning his degree), and returned to his home in California. For the next two decades, much of his work was dedicated to architecture, in order to create on paper the buildings, landscaping, and bridges, that would bring the United States into the new century. This experience would later undoubtedly inform his attention to detail, and his ability to visualize an entire city, on the Moon and Mars.

Although it is not widely known, in this period, Chesley Bonestell contributed to many of the projects Americans see around them every day. In 1916, he worked with landscape architect-engineer Mark Daniels to design one of the best known scenic highways in the United States, along the coast of California.

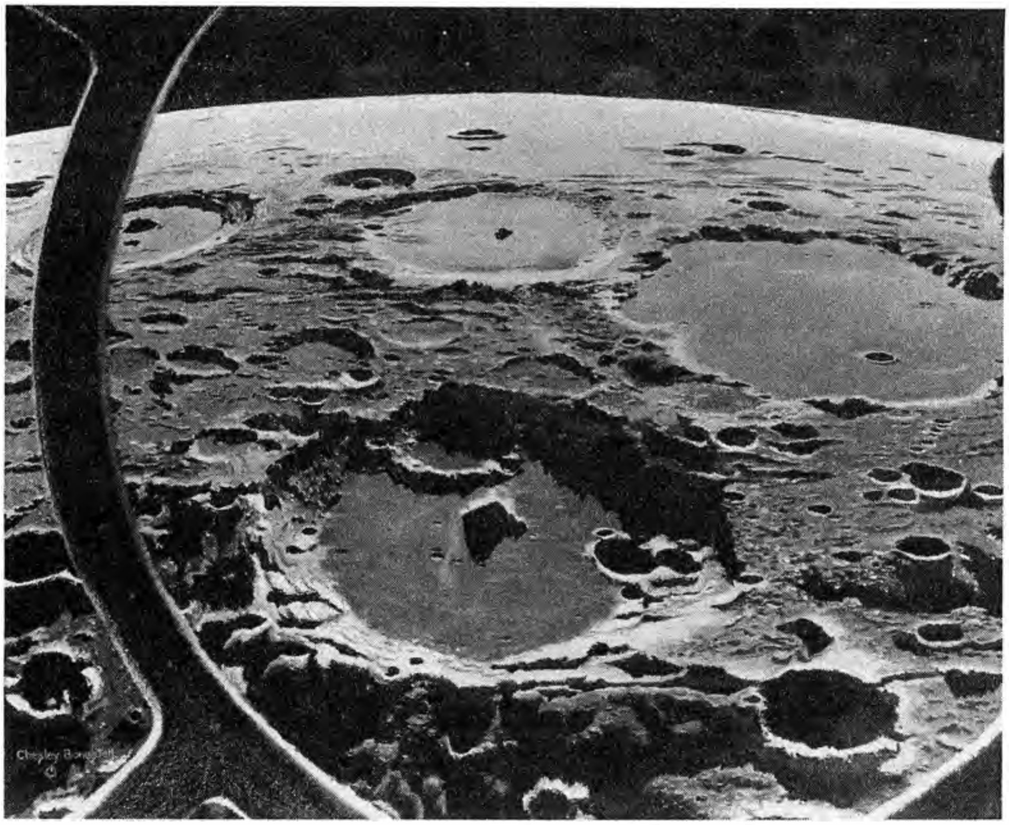
In the 1920s, Bonestell worked with a number of prominent architectural firms in New York, and contributed to the design of the Chrysler Building, and other skyscrapers, in that city. He worked with famed architect Cass Gilbert, on the design of the U.S. Supreme Court Building in Washington, and the state capitols of Minnesota and West Virginia. Bonestell also worked on the design for the Plymouth Rock Memorial in Massachusetts.

After the 1929 stock market crash, and the slowdown of skyscraper construction in New York, the Bonestells returned to California. In 1932,



Illustrations are courtesy of Ron Miller and Frederick C. Durant III

A detail of the Golden Gate Bridge anchors, one of a series of pen and ink drawings by Bonestell in 1935, showing details of the construction of the bridge. The drawings were used to illustrate the publication, The Golden Gate Bridge: A Technical Description in Ordinary Language."



In this view, 200 miles above the crater Albategnius, Bonestell shows us what the Moon's surface will look like, not in an artist's imagination, but to an astronaut looking out the window of his spacecraft. It appeared originally in Life *magazine in 1944, and in* The Conquest of Space, *in 1949.*

Bonestell started a five-year project, producing detailed construction drawings for the building of the Golden Gate Bridge in San Francisco, and contributed to the bridge's final design. He had also contributed to the redesigning and rebuilding of that city, in the wake of the 1906 fire.

During the 1930s, while President Franklin Delano Roosevelt was organizing the government agencies that would rebuild infrastructure to beat back the Depression, Chesley Bonestell created beautiful visual presentations of public works projects that were authorized by the recovery programs.

Bonestell would continue his interest in building great projects for many more years, even after his work turned in other directions. In the late 1940s, Bonestell submitted art work to *Coronet* magazine, some of which was published in 1949, in *Seven Future Wonders of the World.* These unsolicited paintings included the future possibility and design for a bridge across the Verrazano Narrows in New York, a dam across the Yangtze river in China, and a tunnel under the English channel. Fifty years later, these projects have come, or are coming, to fruition.

In 1938, his career took a new turn, and he began a period of working for Hollywood motion picture producers. The limited array of special effects available at that time meant that artist's drawings were needed to fill in panoramic background scenes, where the actors were in actual sets in the foreground. Bonestell produced a lunar landscape for the film, *Destination Moon* in 1950, and contributed to *Citizen Kane, The Hunchback of Notre Dame,* and numerous other films.

But while in Hollywood, Bonestell continued his work in architecture, and, as the authors report, "never lost his interest in astronomy."

A New View of the Solar System

At the end of the U.S. Civil War, French writer Jules Verne used the form of a fictional story to summarize the state of knowledge about the Moon at that time, and make it accessible to a very broad audience. The great scientist Johannes Kepler had done the same, in his *Somnium,* 250 years earlier. In the 20th Century, in 1940, Chesley Bonestell decided to use the medium of paint to provide a view of what he could gather from the scientific community were the features of the Solar System that were as yet unseen.

"[T]he planets of our Solar System had never been accurately depicted from their satellites, through a definite visual angle," Bonestell wrote. "Always before it had been an 'artist's conception.'. . . As my knowledge of the technical side of the motion picture industry broadened, I realized I could apply camera angles as used in the motion picture studio to illustrate 'travel' from satellite to satellite, showing Saturn exactly as it would look, and at the same time, I could add interest by showing the inner satellites or outer ones on the far side of Saturn, as well as the planet itself in different phases."

Thus, he began a series of now-famous studies of Saturn as seen from Titan, and other of its moons. In later years, when observations showed that because Titan is covered in a heavy blanket of clouds, Saturn would not be visible from its surface at all, Bonestell, handled this "mistake" philosophically.

His initial paintings had created a bombshell. He submitted the series of Saturn paintings to *Life* magazine, which published them in its May 29, 1944 issue. As Miller and Durant relate: "No one before had seen such paintings—they looked exactly like snapshots taken by a space-travelling *National Geographic* photographer. For the first time, renderings of the planets made them look like real places and not mere 'artist's impressions.' " These renderings of the planets, which presented them as "real places," would have a profound effect on a number of young people, who would change their plans, and became some of the most fruitful contributors to astronomy and space science.

But Chesley Bonestell's art was about to take another, and most significant, turn. In 1944, at the Hayden Planetarium in New York City, he met Willy Ley, the German rocket pioneer and space writer who had come to the United States in 1937. Ley, who had just completed his seminal work on the history of the brand new field of rocketry, advised Chesley Bonestell to include spacecraft and astronauts in his renderings of space.

Building Cities in Space

In 1949, the first product of this collaboration between an artist and a science writer appeared, as the *Conquest of Space*. The book included 58 paintings by Bonestell, illustrating the text written by Ley, and provided the first "snapshots" to be seen of the lunar surface. These were only to be surpassed by the cameras aboard the unmanned probes sent to the Moon by the Soviet Union and United States in the 1960s.

But the key to the conquest of space, was man. The paintings portray the spaceship ready for liftoff, scenes of the Earth beneath the craft before it heads to the Moon, the flight to the Moon, the way the Moon would look from the window of a spaceship, just above the surface, lunar landings, the establishment of an initial base of operations, and a "weekly transport vehicle" ready to head back to Earth.

Will Ley wrote the introduction to the magnificent book, which he called, "Mostly About Chesley Bonestell." In it, he explained what was required to produce what Bonestell had created, using the view of Saturn from Titan (which Bonestell gave to Ley as a gift), as an example: "...[T]he artist has to know the laws of optics in principle and in detail, since the very first thing that will confront him is a little problem like this: the whole picture will correspond to a visual angle of 30 degrees; the object is 31,000 miles in diameter and will be seen from a distance of 220,000 miles; it will therefore subtend an angle of so many degrees, which will be how much in my picture?"

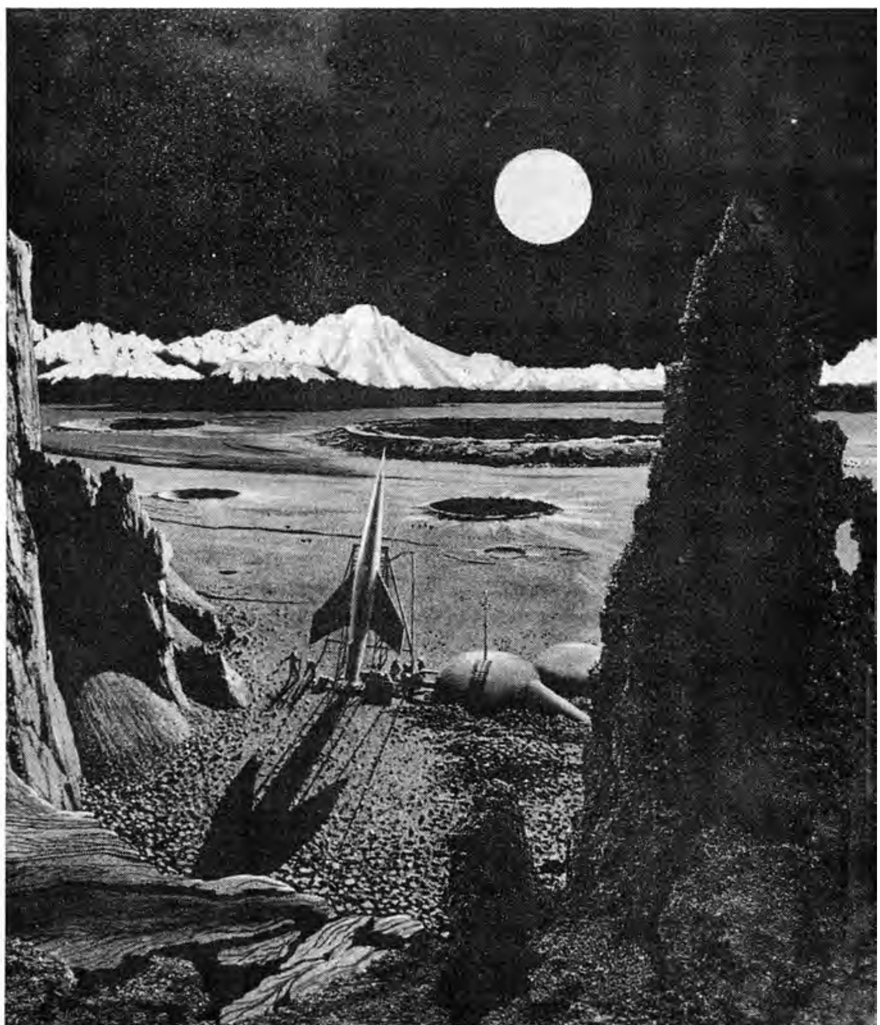
The result," Ley states, "is not an 'artist's conception,' but a picture which you might obtain it if were possible to get a very good camera with perfectly color-true film into the proper position and have it manned by a good photographer who could use just the right exposure with the proper artistic touch. It is obvious that this involves, not just a special talent coupled with special studies, but really an entire life history."

Two years later, Bonestell's vision of manned spaceflight would be extended yet further, with his introduction to Wernher von Braun, at an Air Force School of Aviation Medicine conference in San Antonio, Texas. There, von Braun was signed on to writing a series of article for *Colliers* magazine, for which Chesley Bonestell would be one of the illustrators.

Starting in 1952, and extending over two years, eight magazine articles were published, which covered every aspect of man in space. Young people, their eyes wide, would read about astronaut training, unmanned satellites, winged space shuttles, huge orbiting space stations, lunar landings, and the assembly of gargantuan spaceships, for missions to Mars.

This series of articles, which was later published as a series of books, established not only the outline for the next 50 years in space, as envisioned by von Braun, but actually demonstrated, through Bonestell's art work, that man *could* go into space.

Throughout the 1960s, Bonestell's collaboration with Ley, von Braun, and astronomers and scientists, produced books and articles, including the 1964 *Beyond the Solar System,* where Ley and



Here, Bonestell has painted the beginnings of a lunar base, which appeared in The Conquest of Space. *A weekly transport rocket to Earth is being readied for launch.*

Bonestell take readers on an interstellar flight, and the 1972 book *Beyond Jupiter,* written by Arthur Clarke.

Chesley Bonestell lived long enough to see many of the projects he depicted in paint come into being in reality. Although not all of his artistic representations turned out to be accurate, such as his jagged, rather than rounded, mountaintops on the Moon, Bonestell would modestly say, "even if they're wrong, they did influence young people and got them interested in astronomy, so they at least served that purpose."

In fact, the dramatic representations in Bonestell's art excited and gave new direction to many in the generation of scientists and engineers who later carried out the missions they had seen in the books, articles, television, and the movies, which Bonestell had helped make real.

The Bonestell Treasure

The body of Chesley Bonestell's artwork is a treasure, which has been preserved (in most cases) and catalogued, with some of it in public museums, including the National Air & Space Museum in Washington. That many of his works are also available, in large part, for public use, is the result of the diligent and dedicated work of this book's authors, especially the close friend of the artist, Fred Durant.

The fact that both Durant and Ron Miller —himself a space illustrator and artist—were personal friends of Chesley Bonestell, makes this book not only a unique collection of black and white and color plates of Bonestell's work, but also a warm, personal, and humorous story of this most remarkable man.

Chesley Bonestell created this painting of the Chinese observing Halley's Comet in 240 B.C. for the book, The Solar System, *published in 1961. The painting inspired him to do a whole series of beautiful paintings in Chinese style.*

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The Man Who Inspired The Space Age

Chesley Bonestell (1888-1986) brought the solar system down to Earth, by depicting space scenes not as fiction, but as scientifically accurate views from definite perspectives on a spaceship, a moon, or a planet. Marsha Freeman reviews a book on his work, *The Art of Chesley Bonestell*, from which these illustrations are taken.

Illustrations are courtesy of Ron Miller and Frederick C. Durant III

For the book Mars, *Chesley Bonestell painted this in 1964. The Mars colony is under plastic domes, and dust storms rage in the background at left.*

In preparation for a liftoff from the surface of Mars, the rocket is raised to the vertical position. While the gold and rust-colored soil is true to life, the blue-colored sky resulted from the assurance of astronomers that the Mars sky would be blue.

"The ship, having landed on its tail, will take off from this position for the return to Earth." This is from The Conquest of Space, *published in 1949.*

The separation of the third stage of a manned ferry rocket above the Pacific Ocean. Wernher von Braun, Bonestell's collaborator, chided him that the second stage engine should not be depicted as glowing red hot, because a good engineer would have prevented that by providing an adequate cooling system.

In This Issue:

The Corcoran Gallery of Art, Gift of William Wilson Corcoran

Humboldt's vivid descriptions of how the Andes brought together lush tropical lowlands with the highest of snow-covered peaks, inspired many 19th Century painters, led by Frederic E. Church, to make pilgrimages to Ecuador and Peru, to paint the scenes that Humboldt had described. Here, Church's painting "Tamaca Palms."

ALEXANDER VON HUMBOLDT

'To Represent Nature As One Great Whole'

A naturalist, explorer, and philospher, Humboldt (1769-1859), was above all a nation-builder, one of a tiny handful of passionate republican intellects, who kept the outlook of Benjamin Franklin alive across two generations of oligarchic reaction, to deliver it safely to the age of Lincoln. Timothy Rush re-examines Humboldt's work, and his 1799-1804 travels in the Americas, which captivated the public worldwide, and made Humboldt the most renowned scientist of the first half of the 19th Century.

The Granger Collection

Humboldt collecting plant specimens along the Orinoco, in a famous 1806 oil painting by F.G. Weitsch.