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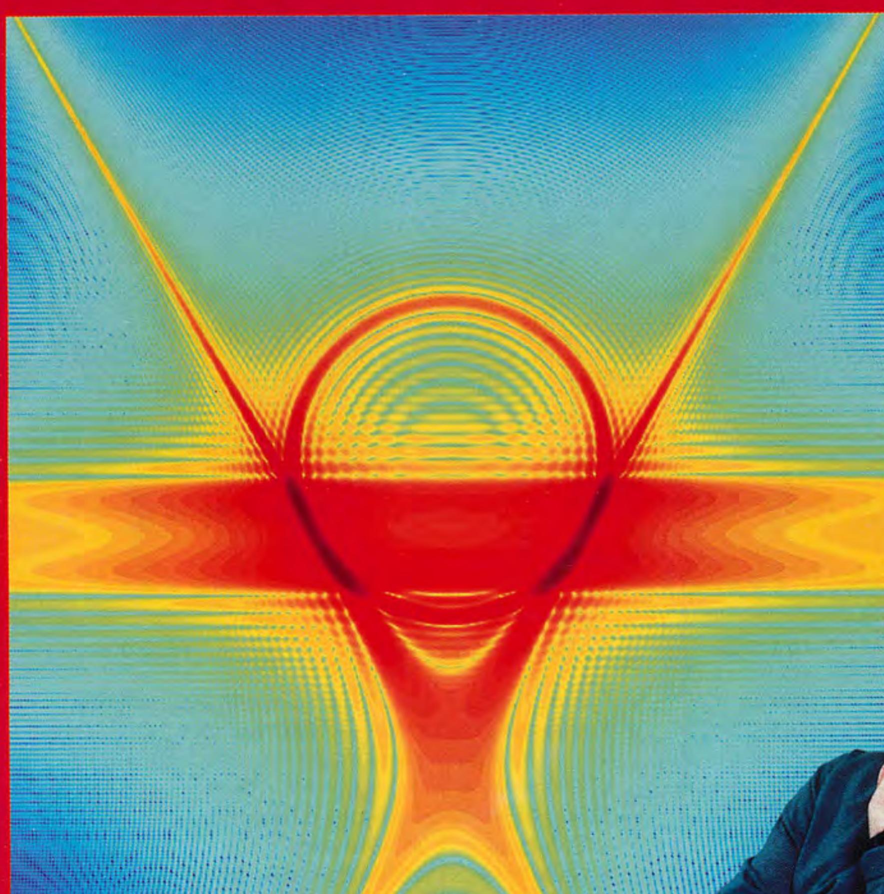
Reflections on Prigoginism



Dr. Ilya Prigogine

- The Latest Biophysics Research Frontier
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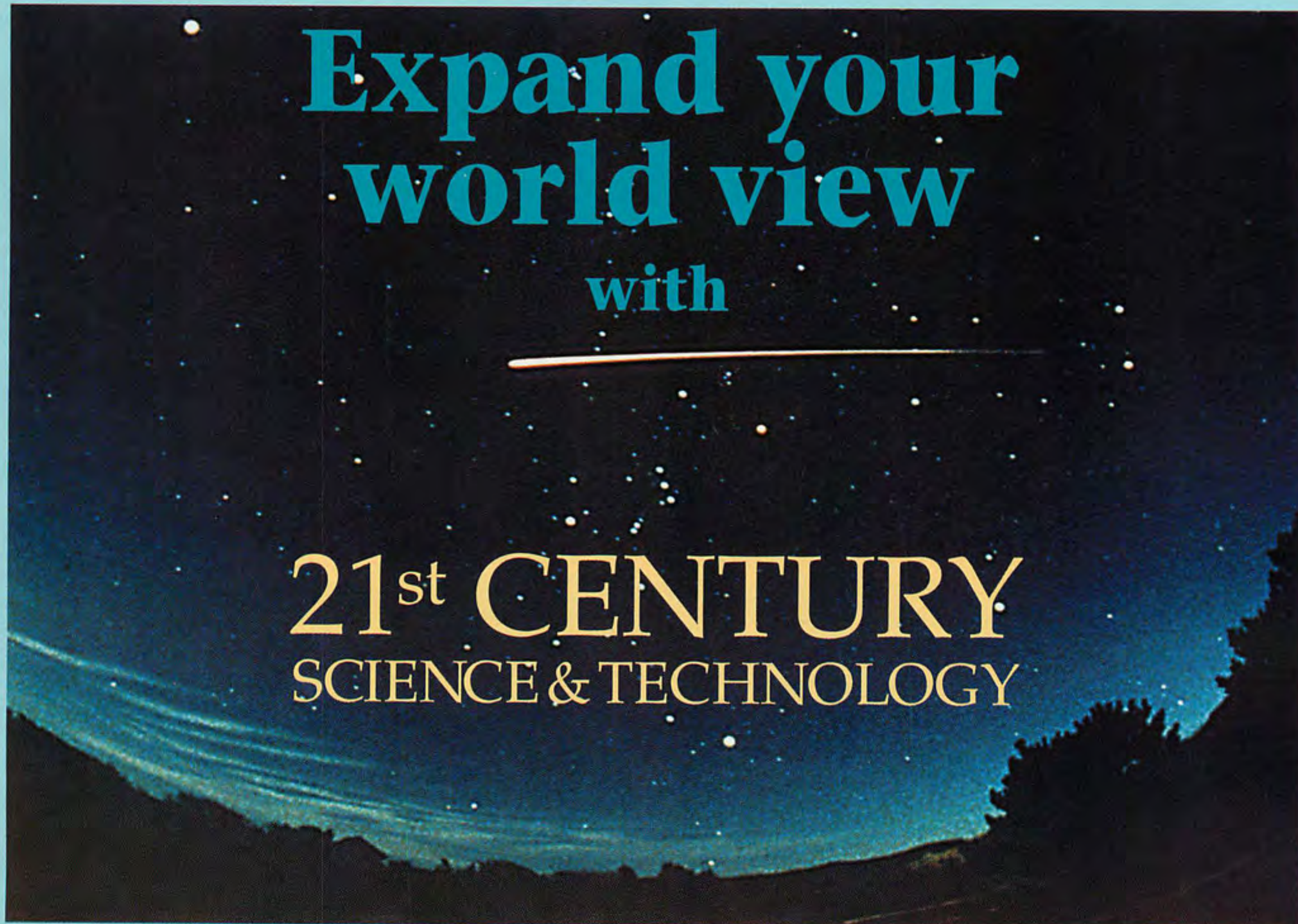

A brilliant Leonid Meteor, streaking across the constellation Orion, Nov. 28, 1999, at Island Beach State Park, New Jersey, photographed by John J. Costello, costellophoto@erols.com

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21st CENTURY SCIENCE & TECHNOLOGY

Vol. 13, No. 1 Spring 2000

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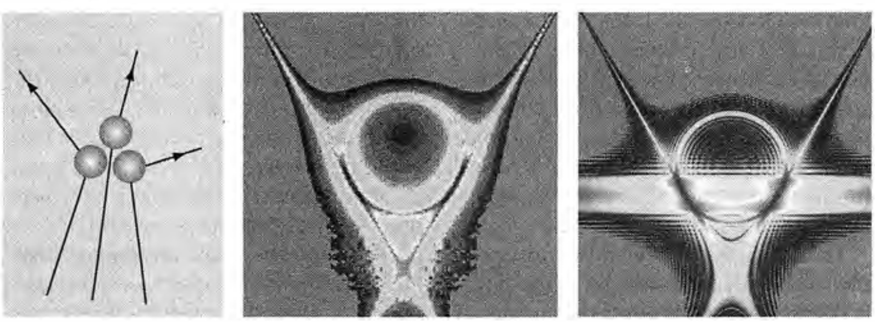

Before During

These diagrams represent mathematical portraits of three hard bodies colliding, according to Prigogine's extended formalism of quantum mechanics. Classical physics cannot predict the behavior of three bodies interacting. In the Prigogine quantum mechanical portrait, only the probability of a certain relative speed between bodies can be predicted. The colors in the plot (on the cover) represent the probability of measuring a certain value of relative speed. Prigogine's formalism is unique in producing the horizontal bar of probability plots, which appears in the "during" model, shown on the front cover.

Source: © Matthew Trump, courtesy of the Ilya Prigogine Center

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On the cover: A three-body collision modeled using Dr. Ilya Prigogine's quantum mechanics, which may be able to describe systems that are time-irreversible. Illustration courtesy of the Ilya Prigogine Center for Studies in Statistical Mechanics and Complex Systems, University of Texas at Austin. Cover design by Rosemary Moak.

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.

Website: www.21stcenturysciencetech.com

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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Subscriptions by mail are $25 for 6 issues or $48 for 12 issues in the USA and Canada. Airmail subscriptions to other countries are $50 for 6 issues. Back issues are $5 each ($6 foreign). Payments must be in U.S. currency.

POSTMASTER: Send address changes to 21st Century, P.O. Box 16285, Washington, D.C. 20041-0285.

Printed in the USA ISSN 0895-682

Time . . . and Philosophical Illiteracy

In one way or another, an unresolved philosophical question seems to lurk behind the considerable responses we received to our last editorial ("Science: To Be or Not to Be, or, How I Discovered the Swindle of Special Relativity"). If one criticizes Special Relativity, it is usually assumed that one thus supports the Galileo-Newton conception of space and time. If one criticizes Maxwell's conception of electromagnetic propagation, it is assumed that one supports the concept of action-at-a-distance.

The matter reminds us somewhat of some recent election campaigns we've seen. Someone says:

"Gore or Bush— make your choice."

"But they're both bozos," you might reply.

"Come on, be realistic. Those are your choices: pick one," they retort.

For myself I have the same answer on all of the above choices: "Neither of the two. I pick LaRouche."

As we are a science magazine, we will focus on the approach taken by Lyndon LaRouche, and his friends, including Gottfried Leibniz, on the question as it relates to the scientific matters. Let us confine ourselves in this short space to a brief consideration of the assumptions underlying the conception of time, which also relates to items raised in this issue's cover story and some related articles.

Time, as it is conceived by most people (especially those trained in the physical sciences), is a product of the human imagination, not of nature. It is, in a word, a prejudice. When we divide the passage of time into homogeneous parts, as by a mechanical clock or other device, we make an assumption, just as we do when we picture space, as arranged along three mutually orthogonal axes, along which we make homogeneous divisions to measure length. To assume, with Paolo Sarpi, Galileo, and Newton, that this *time,* or this *space,* has anything other than an ideal existence, is to indulge a prejudice.

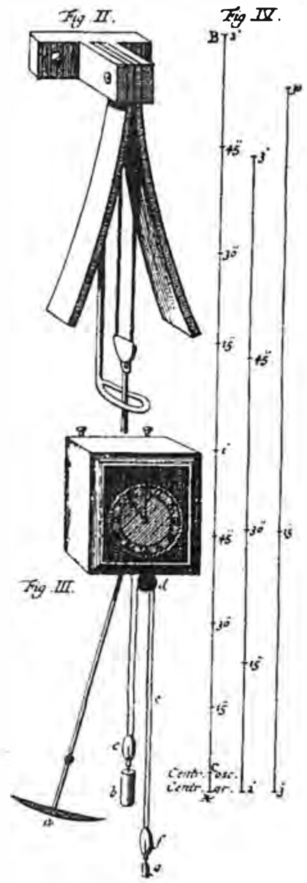
The matter was resolved already, nearly 300 years ago, in the published correspondence between Gottfried Leibniz and Samuel Clarke (the translator of Newton's *Opticks,* who served as proxy for the neurotic mathematician-magician in the debate). As Leibniz stated his position:

"As for my own opinion, I have said more than once that I hold space to be something merely relative, as time is, that I hold it to be an order of coexistences, as time is an order of successions." [Third letter, section 4]

And further:

"I have demonstrated that space is nothing else but an order of the existence of things observed as existing together, and therefore the fiction of a material finite universe moving forward in an infinite empty space cannot be admitted. It is altogether unreasonable and impracticable. For besides the fact that there is no real space out of the material universe, such an action would be without any design in it; it would be working without doing anything, in acting nothing would be done by the action. There would happen no change which could be observed by any person whatsoever. These are the imaginations of philosophers who have incomplete notions, who make space an absolute reality. Mere mathematicians who are only taken up with the conceits of imagination are apt to forge such notions, but they are destroyed by superior reasons." [Fifth letter, section 29]

Although Immanuel Kant famously attempted to restore the discredited notions of an absolute space and time (through the back door of an alleged built-in intuition of same) to respectability in Germany, a towering figure in the sciences, Carl Friedrich Gauss, was



The pendulum clock (ca. 1658) designed by Leibniz's collaborator Christiaan Huygens. The pendulum is suspended by a flexible band which wraps around a segment of a cycloid curve as it swings. Because the cycloid curve is its own evolute, and is isochronic, the clock keeps equal time regardless of the amplitude of swing.

among those who opposed him, even if too quietly.

The assumption, made by the proponents of an ideal time, is that there exists, outside of us, some clock, perhaps only an "ideal" one, beating like a perfect pendulum to divide the hours, minutes, and seconds. The analogous assumption with respect to space, presumes the existence of an absolute "something," a container of sorts, extended in three linear dimensions, infinitely divisible, and in which objects have an existence independent of position—in a word, Euclidean space.

Carl Friedrich Gauss was probably the first to suggest that the question as to the true nature of space and time be subjected to experimental investigation. Gauss was the first to pose the problem of the *curvature of space,* recognizing that there is no reason, other than prejudice, to assume a Euclidean space. His prized student, Bernhard Riemann, addressed the problem more openly in the closing portion of his famous *Habilitation* dissertation, "On the Hypotheses Which Lie at the Foundations of Geometry." Riemann wrote:

"The question of the validity of the postulates of geometry in the indefinitely small is involved in the question concerning the ultimate basis of relations of size in space. . . . A decision upon these questions can be found only by starting from the structure of phenomena that has been approved in experience hitherto. . . .

"This path leads out into the domain of another science, into the realm of physics, into which the nature of this present occasion forbids us to penetrate."

Lost Ground

Unfortunately, because of the condition of almost perfect philosophical illiteracy that has overtaken us today, we have mostly lost ground in respect to the investigation of so important a question as this.

We are thus pleased to present in our cover story a thought-provoking examination of the work of Nobel laureate Ilya Prigogine, which we hope will serve as partial antidote to the referenced unletteredness, that so pervades and enmires our culture today. There, author De Paoli contrasts LaRouche's totally unique conception of "the simultaneity of eternity," conceived in part in reflection upon the notions of time-reversibility taken up by Andrei Sakharov, as opposed to the linear "time" of Prigogine. We also call the reader's attention to the comments of Moscow biologist Vladimir Voeikov, concerning the groundbreaking work of Russian physicist Simon Shnoll: "Shnoll's work shows that time is heterogenous. It's not a Newtonian time. Each moment in time is different from another, and this can be seen in any physical processes which you study. His results show that there is information, cosmic information, which is affecting all the processes on Earth."

We expect to be hearing more about this interesting work . . . in due time.

—*Laurence Hecht*

Letters

On Understanding The Fraud of James Clerk Maxwell

To the Editor:

Among the criticisms of James Clerk Maxwell in the editorial of your Winter 1999-2000 issue ["Science: To Be, or Not to Be, Or, How I Discovered the Swindle of Special Relativity"], the only specific one was his "introducing the concept of a magnetic field." According to my old college texts, it was Faraday (born 40 years before him, in 1791) who first conceived of magnetic and electric fields and their (imaginary) lines of force. And how would you disprove such fields?

An electrical engineer, I forced myself to read Maxwell's *Treatise on Electricity and Magnetism* all the way through, about 20 years ago. The man took the experimental researches of others (giving them credit), and, making some assumptions (which he admitted), assembled a textbook of clear explanations and the mathematics involved. Without Maxwell, electrical engineering would not have advanced as rapidly. Maybe the man was wrong here and there, maybe the electron theory of electricity is not entirely right, but Maxwell's work is internally consistent and checks experimentally.

There is hardly a modern theoretical electrical engineering paper that does not cite Maxwell's four basic equations. Maxwell was practical too: I was surprised to find that methods of calculation for networks and for electrostatic induction among an array of wires, that I had been using, were exactly those described in his book.

Maxwell's electromagnetic theory of light is apparently still accepted. To explain this, he used the concept of the ether (conceived by Huygens in 1678); this has never been disproved and is coming back into favor.

In an age when many scientists doubted the possibility of "action at a distance," Maxwell predicted what is now called radio, and provided the mathematics for both the radiated field and the nearby induction field.

It is hard for me to see any justification for your editorial calling Maxwell " . . . the great British faker. . . ." And what is the evidence for ". . . British political-military hegemony at the time . . ." imposing Maxwell's views on reluctant opponents?

Benson Boss
Deming, N.M.

The Editor Replies

If you want to understand the fraud, start by looking at what Maxwell (and before him Faraday) were so intent on resisting—that is, the electrodynamics of Ampère, Gauss, Weber, and Riemann.[1] I would venture to guess that you have never read their original work. Yet, these were the *discoveries*—the real, exciting, and hard-won breakthroughs—upon which Maxwell bases his mathematical reformulations.

If you do not know them, you will not understand, among other things, why the replacement of the Ampère-Gauss-Weber-Riemann approach by Maxwell's formulations, greatly slowed down progress in all science, including electrical engineering, and more important, in our understanding of the microphysical domain.

There is an essential matter of method involved here which you, among many others, are failing to see. That is, that a fundamental discovery concerning natural processes in the universe is not the same as the algebraic formula, or verbal formalization, by which it is later represented. Until you understand and re-experience for yourself, the difficulties, uncertainties, and passionate excitement—which the discoverer has gone through to arrive at his breakthrough—you cannot claim to understand it. And, since all human knowledge of the universe is necessarily partial and incomplete, you will also be in no position to contribute to the advancement of knowledge, if all you know is the end result, but not the subtleties, the real "ins and outs," of the process of discovery that came before.

Most textbook writers today pass over this part with a gloss, in order to get to the "bottom line," which in science and engineering is usually the working formula. That is why we argue: "throw out the textbooks." Real education begins when the student, of whatever age, develops the intellectual passion, the love for truth (which Plato and St. Paul called *agape*), to relive the original discoveries. This brings with it a concentration span and perseverance that need not be forced, for such effort, one soon discovers, is a joy, perhaps the greatest we can know, and not a chore.

Maxwell devoted much of his life to coming up with an alternative mathematical formulation of the electrodynamical discoveries that had been made by Ampère and Weber, to put them in a mathematical form consistent with Faraday's field-line conception. He justified the effort, much like a modern-day pluralist, by arguing that there is no harm in trying an alternative representation. (It seems that practice is so prevalent in so-called theoretical physics today, that most fail even to see that there is anything wrong with it.) But, as the work of Riemann shows most clearly, there is a fundamental philosophical difference between the two approaches that is not addressed by the pseudo-dichotomy, affirmed by Maxwell, between *field* versus *far-action* theories.

On the brutal imposition of Maxwell's ideas in Germany, after the death of Kirchoff, see the autobiography of Serbian-American physicist Michael Pupin, which was popular in the 1930s. Max Planck also makes reference to the matter, as do many others of his generation. In France, there was also a battle. In America, E.H. Hall put up an interesting fight against the hegemony of Maxwell, which led to his famous discovery of the Hall Effect (1879). Earlier, American Association of Science founder Joseph Henry had had to straighten the record concerning some of Faraday's undue claims.

Notes

1. For an introduction to the Ampère-Gauss-Weber electrodynamics, and reference to original sources, see Laurence Hecht, "The Atomic Science Textbooks Don't Teach: The Significance of the 1845 Gauss-Weber Correspondence," *21st Century*, Fall 1996, pp. 21-43; and Jonathan Tennenbaum, "An Introduction to 'The Significance of the 1845 Gauss-Weber Correspondence,'" *ibid*, pp. 2-5.

For English translation of some of Riemann's works, and an introductory overview by Lyndon H. LaRouche, see "Riemann Refutes Euler," *21st Century*, Winter 1995-1996, pp. 36-62.

Fusion for the Millennium!

To the Editor:

I just wanted to let you know how much I appreciated the report on fusion energy in the Winter 1999-2000 issue ["Fusion Energy—20 Years Later" by Marsha Freeman, p. 8].

I heard and read so many prophecies about the new century and new millennium, but not one word about energy from fusion. I do not know how many billions of dollars we spend importing oil every year; we are terrified about the pollution it causes; we fret about global warming; we spend hundreds of billions a year for alcohol, tobacco, and other substances that actually hurt us—but we are not willing to spend $1 billion a year for developing fusion power.

Don't people have any imagination? Can they not see what we could do with an unlimited, non-polluting supply of energy? Of course, it will take some time to get going, but look at all the rest of technology we have already that could be used. We know how to distill water for drinking and irrigation, to eliminate all hunger. We have raw materials for different metals and other building materials in unlimited supply, to fulfill all basic needs from planet Earth. All we need is the energy for fabricating.

Even if we cannot use fusion for propulsion of spaceships right away, it still would give space travel and colonization a very big boost.

Thank you so much for the work you do to promote these two fields of research so important to the future of humanity.

Hans Petri
Wood Dale, Ill.

Abiogenesis of Oil Questioned

To the Editor:

I enjoy reading your magazine for its breadth of perspective and willingness to describe deep physics in terms that I (a geologist) can comprehend. . . .

Concerning the review of Thomas Gold's 1999 book, *The Deep Hot Bio-*
(Continued on page 12)

Discovery of H_2 in Space Explains Dark Matter and Redshift

by Paul Marmet

In papers published about a decade ago, the author and colleagues predicted the widespread presence of hydrogen in the molecular (H_2) form in space (Marmet and Reber 1989; Marmet 1990a, b). Although hydrogen in the atomic form is easily detected through radioastronomy, the molecular form is difficult to detect. We showed that the presence of this missing mass would explain the anomalous rotational motion observed in galaxies, which is otherwise explained by exotic hypotheses, such as swarms of invisible brown or white dwarfs, or weird atomic particles called WIMPs or axions, and "quark nuggets."

We also showed that the presence of large amounts of the hard-to-detect molecular hydrogen in interstellar space could provide an alternative explanation to the Big Bang theory, by explaining the observed redshift as a result of the delayed propagation of light through space, caused by the collision of photons with interstellar matter.

European Space Agency

New data from the European Space Agency's Infrared Space Observatory (ISO), show huge amounts of molecular hydrogen in space—as predicted by this author a decade ago. Here, an artist's illustration of the ISO.

The more commonly held view explains the observed shift in frequency of the spectral lines detected from distant galaxies as arising from a Doppler shift (a shift in the frequency of a wave caused by the relative motion of the emitting object and the observer). The downshift in the frequency, toward the red end of the spectrum, is taken to mean that distant galaxies are receding from us, thus implying an expanding universe.

Our prediction, based on a critique of many of the commonly held assumptions of cosmology, was the result of a serious study of the molecular structure of hydrogen and of the astronomical observation of atomic hydrogen in space. However, the astrophysicists preferred to ignore H_2, and instead to hypothesize the existence of weird objects.

Using the European Space Agency's Infrared Space Observatory, E. A. Valentijn and P. P. van der Werf recently detected huge amounts of molecular hydrogen (H_2) in NGC 891, an edge-on galaxy 30 million light-years away in Andromeda (Valentijn and van der Werf 1999). In their report, published in September 1999, they state that their result "matches well, the mass required to solve the problem of the missing mass of spiral galaxies." They conclude that the galaxy contains 5 to 15 times more molecular than atomic hydrogen.

It is generally accepted that atomic hydrogen is by far the most abundant particle in the universe. It is also well established that about 10 times as much molecular hydrogen as atomic hydrogen solves the missing mass problem. Finally, Valentijn adds: "The halo culture that has grown up around the dark matter problem might never have arisen if the ISO results had been known earlier."

Two months after the publication of this discovery, in a piece published in *Nature,* Nov. 25, 1999, P. Richter, et al. reported the discovery of the absorption lines of molecular hydrogen in a high-velocity cloud of the Milky Way halo (Richter et al. 1999).

Nature of Molecular Hydrogen

Molecular hydrogen is rarely looked for in space. In most papers in astrophysics, the word *hydrogen* is mentioned without distinguishing whether it is atomic or molecular. Yet it is a well-known fact of basic chemistry that atomic hydrogen is extremely unstable, and that it reacts violently to produce molecular hydrogen, which is extremely stable. Given a bottle of pure atomic hydrogen, one would expect an immediate energetic explosion, producing molecular hydrogen at a very high temperature.

Atomic hydrogen (H), composed of a single proton and electron, is the simplest existing stable atom. Because of the spin structure of the particle, it is easily detectable using a high frequency radio signal at 21-cm wavelength. Atomic hydrogen in galaxies and in intergalactic space can be detected very easily, because the atomic hydrogen can change its spin (which changes its energy).

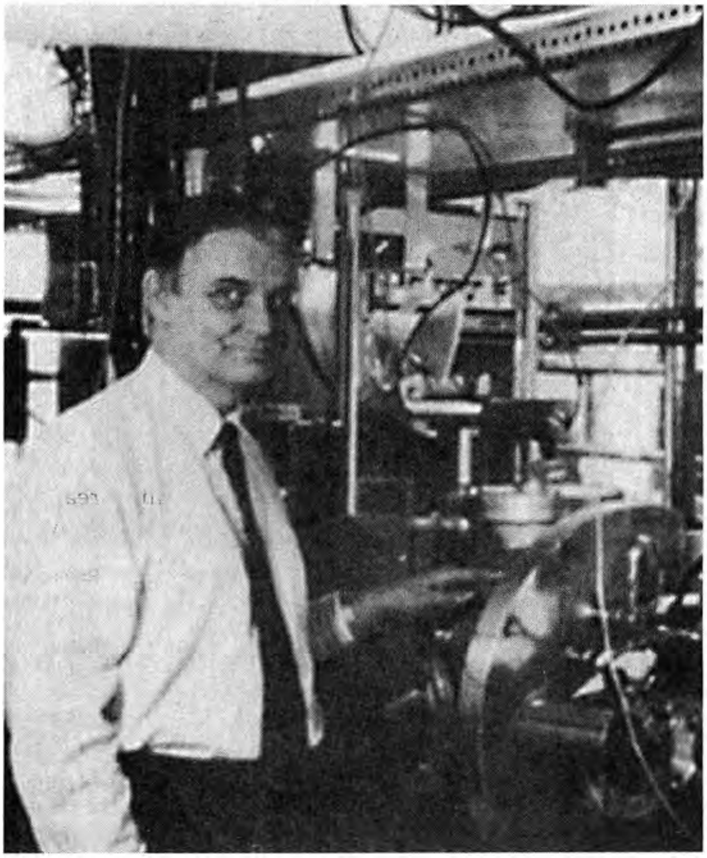
Electromagnetic radiation is emitted at the wavelength of 21 cm, or an absorption line is observed (in the background radiation) at that wavelength. However, when two atoms of atomic hydrogen combine, forming molecular hydrogen (H_2), their spins are coupled and completely cancel each other. The radio-frequency spectral line at 21 cm no longer exists, and the molecular hydrogen becomes totally invisible at that wavelength.

The possible vibrational and rotational states for the two hydrogen nuclei in the diatomic hydrogen molecule are well known (cf. Herzberg 1950). However, the only two electrons are so tightly coupled, that they form a pair in which the electric field and the spin of the electrons are completely cancelled.

Molecular hydrogen possesses no permanent dipole. Such a perfect coupling is unusual among diatomic molecules. For example, in the cases of nitrogen and oxygen, there are seven and eight electrons per atom, so that when combined, it is not possible to fulfill such a perfect coupling of spins (with zero permanent dipole) for all seven or eight pairs of electrons.

When light passes through normal molecular gases, such as oxygen, nitrogen, and others, radiation excites the resulting electric dipole in the molecule, and some energy is scattered or absorbed. However, in the case of molecular hydrogen, there is no dipole moment, so that no radiation can be absorbed or emitted.

Most excited molecules possess an electric or magnetic dipole, and emit photons (light) after about 10^{-8} seconds. By comparison, the spontaneous emission of light from the first rotational state of molecular hydrogen is practically impossible. A transition from the second rotational state (producing a photon of light) is relatively much more probable, but occurs only once in about every 1,000 years. One must reach the sixth state before the probability of the transition occurring becomes once a year. These so-called forbidden transitions are so improbable that we cannot hope to detect cold molecular hydrogen in space. Because the universe has an average temperature of 3°K, the detection of most of the molecular hydrogen still remains unlikely.



Paul Marmet, shown with the electron spectrometer that he pioneered, at the Herzberg Institute of Astrophysics. The spectrometer produces a low-energy, monoenergetic electron beam, which is used to study aspects of the electron structure of atoms and molecules, such as their energy levels.

The electron beam is fired into a beam of atoms or molecules, directed at right angles to it. The number of ions produced in the resulting interactions provides the information about the electron configurations in the atoms and molecules. Marmet has studied atoms of helium and argon and molecules of molecular nitrogen, molecular oxygen, carbon monoxide, and methane, among others.

Why the Surprise

The extreme transparency of molecular hydrogen in different quantum states may also be examined (Marmet 1992). Compared with all other known gases, molecular hydrogen is the most transparent in the universe. Yet, this well-known fact, should have led to the expectation of finding molecular hydrogen, because atomic hydrogen had already been observed. It is difficult to understand why it was ignored, when so many experimental observations require the presence of missing mass in the universe.

There are many misleading statements concerning the detection of hydrogen in the universe. Without making any distinction between atoms and molecules, most papers in *astrophysics* state that the amount of hydrogen in the universe is well known because it is easily detectable out to considerable distances. The presence of an enormous amount of molecular hydrogen certainly makes this statement erroneous.

However, it is well known that atomic hydrogen in space was certainly naturally transformed into H_2. Over billions of years, dust, three-body interactions, and even photon emission have produced H_2. Once molecular hydrogen is formed, it is so stable that it has little probability of dissociation. It cannot be argued that H_2 does not exist in space because it could be ionized or dissociated by ultraviolet radiation. If there were enough ultraviolet radiation to ionize H_2, that same radiation would also ionize atomic hydrogen. This is not the case, because non-ionized atomic hydrogen is observed, even though it requires less energy to ionize the atomic than the molecular form of hydrogen.

These considerations show, that as a result of the large amount of atomic hydrogen already observed in space, and the extreme stability of molecular hydrogen, the chemical equilibrium giving the relative abundance between atomic hydrogen and molecular hydrogen in space, strongly favors the formation of the diatomic form (H_2) over the monoatomic form. We must thus conclude that the recent discovery of H_2 is no surprise, and should have been expected from the known facts concerning the natural equilibrium between H_2 and H. It is expected that much more colder H_2 will also be discovered.

Dark Matter and the Redshift

The presence of H_2 also has important consequences regarding the origin of the universe and the interpretation of the cosmological redshift. This author has been arguing for several years that this huge amount of transparent H_2 in space is interacting with light received from the cosmos (Marmet 1988, 1990a, b). The essential argument is summarized as follows:

Even when H_2 is not excited to specific quantum states, there is another kind of interaction that perturbs and slows down the moving photon. We know that light interacts with a transparent medium, because its velocity is reduced, without scattering, as calculated and observed using the simple index of refraction of gases. Cosmic light, moving across billion of light years, suffers an almost unimaginable number of collisions with those transparent molecules of hydrogen in the universe.

Light is a wave-train of electromagnetic radiation. As a result of its coherence, which is maintained during a time span (known as the time or length of coherence), the phase of the electromagnetic field progresses regularly in time. Using the Fourier transform, we can calculate that an electromagnetic wave train (which never can last an infinite time), always possesses two frequency components: the usual high-frequency component, but also a very low frequency component, which depends on the time of coherence.

From the electron-proton structure of hydrogen, it can be calculated that some energy is lost (scattered) during the interaction of light with hydrogen, which depends on that low-frequency component (time of coherence). We have shown that the passage of light through hydrogen, either atomic or molecular, is always (slightly) inelastic. It is also known that the energy loss is compatible with the relationship $\delta\lambda/\lambda =$ constant. Consequently, the redshift following the collision of a photon with H_2 is indistinguishable from the phenomenon caused by the Doppler effect.

Only the warmest molecular hydrogen (involving higher vibration and rotation quantum numbers) is detectable now. When the technology develops to the point that we can detect the colder H_2 in the universe, a larger quantity of H_2, coming from colder molecular hydrogen in galaxies, will certainly be discovered.

"The Doppler interpretation of the redshift is a variation of the Creationist theory, since it claims that the universe was created from nothing, 15 billion years ago, with a sudden Big Bang."

We know that the H_2 molecule produces about the same (non-Doppler) redshift as monoatomic hydrogen, but the number of H_2 molecules is much larger. Because atomic and molecular hydrogen have an approximately homogenous distribution in the universe, this induces a non-Doppler redshift, which is proportional to the distance of the light source (just as for an apparently expanding universe, assumed with a Doppler interpretation).

The recent discovery of an enormous quantity of molecular hydrogen not only solves the problem of missing mass; it also solves the problem of the redshift, in a non-expanding unlimited universe. The Doppler interpretation of the redshift is a variation of the Creationist theory, since it claims that the universe was created from nothing, 15 billion years ago, with a sudden Big Bang. Since a much larger amount of molecular hydrogen than previously admitted has been observed in the universe, we can now see how this hydrogen is responsible for the redshift observed. That molecular hydrogen is responsible for the redshift which is erroneously believed to have a cosmological Doppler origin.

It is unfortunate that the existence of H_2 has been ignored for so long. As noted by one of the recent discoverers, E.A. Valentijn, the missing mass problem might never have arisen if the Infrared Space Observatory results (or predictions of H_2) had been known earlier. It is also true that the problem would not have arisen, if the arguments presented by this author and others for the necessary presence of H_2 had been heeded.

With the new discovery, science can now have a logical and realistic description of nature, because we no longer have to speculate with such exotic hypotheses as WIMPs and "quark nuggets" to explain the missing matter in the universe.

Dr. Paul Marmet recently retired from the Physics Faculty at the University of Ottawa. He was formerly a senior researcher at the Herzberg Institute of Astrophysics of the National Research Council of Canada, in Ottawa, and from 1967 to 1982, he was director of the laboratory for Atomic and Molecular Physics at Laval University in Quebec. A past president of the Canadian Association of Physicists, Marmet also served as a member of the executive committee for the Atomic Energy Commission of Canada from 1979 to 1984.

He is the author of Einstein's Theory of Relativity vs. Classical Mechanics, *published by Newton Physics Books in Gloucester, Ontario. Marmet can be reached by e-mail at Paul.Marmet@ottawa.com.*

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U.S. Uranium Enrichment Privatized to Death?

by Richard Freeman

On Feb. 4, 2000, Standard and Poor's rating agency downgraded the credit rating of the United States Enrichment Corporation (USEC) to "below investment grade"—that is, to junk-bond status. USEC is the largest commercial enricher of uranium in the world, enriching three-quarters of America's uranium, and one-third of the world's.

The process of enrichment concentrates uranium material to a level at which it can be used as fuel in a nuclear reactor. Without it, nuclear power is impossible—and nuclear power is indispensable for America to power its homes and its factories, now supplying about 20 percent of America's electricity.

The downgrading of USEC could place it in financial danger, and hence jeopardy overall—and with it, our entire economy.

Intensifying this crisis is the fact that USEC, which once functioned relatively efficiently as a part of the U.S. Department of Energy, was privatized by the financial pirates of the Conservative Revolution and George Bush's administration, turning soluble problems into intractable ones.

The Enrichment Process

Uranium is a naturally occurring element containing U-235 and U-238 isotopes; only U-235 is fissionable in a power plant. Just after it has been mined, natural uranium contains only about 0.7 percent U-235; to make the uranium usable as fission fuel, the concentration of U-235 must be increased to 4 percent to 5 percent.

There are two main commercial technologies for enrichment: gaseous diffusion and the gas centrifuge. (The use of lasers for isotope separation, in particular the Atomic Vapor Laser Isotope Separation system, known as AVLIS, was explored in the 1980s, and was expected to cut the total costs of the enrichment process by two thirds, but the development of this technology was dropped, as part of the short-

Stuart Lewis/EIRNS

sighted cost-accounting that goes hand-in-hand with "privatizing.")

At its two plants at Paducah, Kentucky, and Portsmouth, Ohio, USEC employs the gaseous diffusion method, which makes use of the mass differences between U-235 and U-238. The converted form of uranium, uranium hexafluoride, which has been heated to a gas, is passed through a semi-porous membrane, separating out the lighter U-235 from the heavier U-238.

It once was the case—for several decades—that the U.S. government owned and operated the Paducah and Portsmouth plants, both of which were built in the 1950s. Until 1969, the plants operated almost exclusively for national defense purposes. At that point, they began to enrich uranium for the commercial nuclear power sector as well. They operated on an efficient *and profitable* basis, which profit was turned over to the U.S. government.

Privatization

But then, in 1992, the privateers, following the political lead of British Prime Minister Margaret Thatcher, pushed through Congress the Energy Policy Act of 1992, which President Bush signed into law. This created the United States Enrichment Corporation as a government corporation, and set out a process and timetable by which the USEC would go private. A privatized USEC would lease out the government's enrichment plants, and run them on a for-profit basis. The claim was that this would be more "efficient."

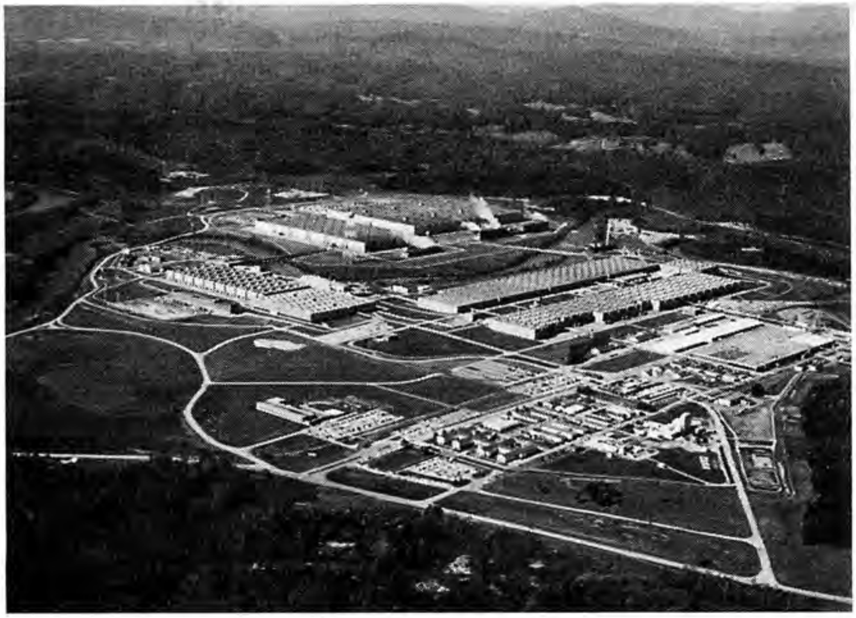
In reality, the privatizers had their eyes fixed on the profitable income stream, which already existed, and which they hoped to make their own—an income stream that resulted from the government's investment of significant sums for plant and equipment for 40 years.

Finally, in July 1997, USEC was privatized, and on July 28, 1998, an Initial Public Offering was made, bringing in $1.9 billion.

Once they had gotten it privatized, USEC's privatizers had to run a company. One of the matters USEC had to confront was a 1993 agreement between the governments of Russia and the United States, under which Russia would take down nearly 20,000 nuclear warheads. Because the nuclear material in a nuclear warhead is in a much more highly enriched state than is the uranium used in fuel assemblies in a nuclear reactor, the agreement stipulated that the Russians would convert 500 metric tons of highly enriched uranium (HEU) from dismantled warheads into low enriched uranium (LEU), to be used as fuel to generate electricity.

In 1994, the implementation of this agreement led to a 20-year contract, whereby the U.S. federal organization that was the predecessor to the USEC agreed that it would buy LEU fuel from Russia, after the Russians had converted it from HEU, and then would sell the LEU to utilities as fuel for nuclear power plants. Rather than allowing the LEU to be stolen from them for a song, the Russians sold it at fair market price. This agreement, in addition to its political aspects, meant that the Russians did not suddenly sell off large quantities of LEU, which would have collapsed the price.

For a variety of reasons, the price of LEU has fallen. The privatized USEC is now complaining that it must pay the Russians $89 per separative work unit



DOE

The Gaseous Diffusion Plant at Oak Ridge, Tenn., was constructed in 1943 and began producing enriched uranium for the Manhattan Project two years later. Its initial power consumption equalled that of the entire Soviet Union in 1939!

(the separative work unit is the level of effort required to increase the concentration of U-235 in natural uranium). Starting from scratch with uranium hexafluoride, the cost of production per separative work unit is only $79 in the United States.

The USEC claims that it is trying to renegotiate the price on the Russian deal, which is either losing the USEC money, or not making it as much as it would like.

However, based on its other work, the USEC is still profitable. For the six months ending Dec. 31, 1999, the USEC made $48 million—which, although just half of what it made for the same period in 1998, would give it annualized profits of more than $100 million. Were the USEC still owned and run by the U.S. government, the chimera of total profit size would not drive everything. The operation would still be run on a healthy, efficient basis.

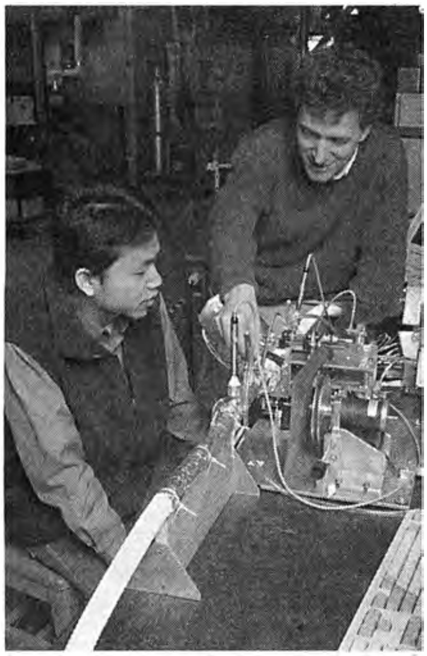
But USEC is private. Its lowered earnings have caused a drop in its stock price by 60 percent. When it was formed, USEC fired 500 workers; then, on Jan. 4, 2000, it fired another 850 workers, from a workforce once 5,000 strong. It has spent hundreds of millions in a stock buy-back plan to support its stock price.

This is directly the opposite state of affairs that would exist, if the United States had pursued the Atoms for Peace program, which envisioned 2,000 nuclear plants worldwide, by the year 2000. The implementation of that program would have greatly increased the demand for LEU, and would have brought on line the more advanced AVLIS laser separation enrichment process, as well as advanced nuclear plants.

To recapitulate: USEC enriches fuel for three-fourths of America's 100-plus nuclear power plants. The downgrading of USEC's credit rating to "below investment grade" jeopardizes the company. That, in turn, could lead to a government bailout, or—what would be far more serious—threats to America's nuclear cycle, and our economy overall.

That's the magic of privatization: an out-and-out swindle.

Richard Freeman is an economics writer for Executive Intelligence Review.



David Umberger/Purdue News Service

Luc Mongeau (right) and doctoral student Zhaoyan Zhang work on a model designed for studying the aerodynamics of human speech.

MODEL OF LARYNX REVEALS 'SMOKE RINGS' IN HUMAN VOICE

Engineers at Purdue University in Indiana are using plastic and mathematical models to re-create and analyze the voice production process, which depends on turbulent air flow through the glottis, an opening in the larynx (voice box). As air flows through the model, its rubbery walls are rapidly adjusted by small rods to simulate how the tissue responds during speech. This strategy is different from the conventional approach to speech synthesis, which ignores human physiology, says Luc Mongeau, Associate Professor of Mechanical Engineering at Purdue.

The voice process begins when the lungs exert air pressure and the vocal cords open, releasing successive, pulsing jets of air, he explains. Each jet of air is attached to a leading vortex, which resembles a smoke ring that eventually detaches from the jet. The time it takes for the ring to detach from the jet—about one thousandth of a second—is critical to the formation of speech. "Think about smoking a cigarette and making smoke rings. If you make them very slowly, the rings have time to go away, and you can watch them dissipate. But you could also puff them in close succession, and that's when you get what I call a vortex train, one vortex following another, and it looks like a caterpillar," said Mongeau.

"We looked at that process with a magnifying glass in a big computer simulation," Mongeau said. "What we want to know is, how much jet development you have during that period of time, and is that sufficient for a single vortex to form and detach, or would it stay attached until the formation of another one?" Recent findings of this study are reported in a paper in the March issue of the journal *Physics of Fluids.*

EPIDEMIOLOGIST SHOWS THAT WARMING WON'T INCREASE MALARIA

Malaria was a widespread killer and crippler in England and other European nations during the coldest years of the Little Ice Age, in the late 1500s, reports epidemiologist Paul Reiter, chief of the Entomology Section Dengue Branch of the U.S. Centers for Disease Control. Reiter documents this through epidemiological and other historical records, as well as the literature of Shakespeare and Defoe, in an article in the Jan.–Feb. 2000 journal *Emerging Infectious Diseases.*

Reiter's point, directed against the global warming publicists, is that the mosquito vectors for malaria can, and did, live and transmit disease in cold and temperate climates, but, over time, swamps were drained, window screens were used, and pesticides, especially DDT, were able to drive down or eliminate the mosquito populations.

The English word for malaria was "ague," which remained in common usage through the 19th century. "The strongest evidence that ague was indeed malaria," Reiter says, "is the identity of its cure": an extract of cinchona powder, made from the bark of several native South American trees, which has as its principal ingredient quinine. This effective use for malaria therapy, he says, was first developed with ague patients living in the salt marshes of Essex, less than 50 km from the center of London. . . ."

The increase in the incidence of malaria today, Reiter notes, stems from the deterioration of public health services and of mosquito control, increased international travel, and natural disasters and civil strife. "Public concern should focus on ways to deal with the realities of malaria transmission, rather than on the weather," Reiter says.

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Grilled irradiated beef and chicken: salmonella free. Ask for irradiated products at your local supermarket this spring.

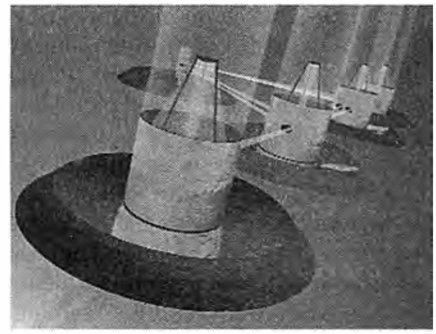
IRRADIATED BEEF AND CHICKEN CELEBRATED ON CAPITOL HILL

Freshly grilled irradiated beef and chicken were served to members of the Agriculture Committees of the House and Senate, as well as the press, Feb. 17, in celebration of the final approval of red meat irradiation regulations, issued Feb. 22 by the U.S. Department of Agriculture. The burger event was sponsored by Food Technology Services, Inc. of Mulberry, Florida (formerly called Vindicator), and MDS Nordion, an international supplier of irradiation technology.

NASA PLANET-HUNTING CONTRACTS AWARDED BY JPL

Four industrial-academic teams were awarded contracts in March by the Jet Propulsion Laboratory, to design the Terrestrial Planet Finder, a mission that will look for possible planets around other stars. "The challenge is like trying to locate a firefly next to the beam of a brilliant searchlight," said Dr. Charles A. Beichman of JPL, who is the project scientist for the mission.

The mission is planned to launch in 2012, and to look at 250 stars over a five-year period, making thousands of images with a sharpness that is 10 to 100 times brighter than those of the Hubble Space Telescope. The teams will be led by Ball Aerospace, Lockheed Martin Space Systems, TRW, and SVS; they represent about 75 scientists from 30 universities and research institutions, and 16 industrial firms. For more on NASA's overall planet-finding project, see "The Growing Evidence of Planets Beyond Our Solar System," p. 46.



Jet Propulsion Laboratory/NASA

One design for the Terrestrial Planet Finder. The mission requires development of many challenging technologies, including those necessary to fly several 3.5 meter (137-inch) telescopes in precise formation, down to a fraction of a centimeter, even though the telescopes will be a distance of several football-fields apart.

REPORT PLAYS DOWN FEARS OF GLOBAL WARMING HEALTH EFFECTS

A 12-member blue ribbon scientific panel, headed by Jonathan Patz of the Johns Hopkins University School of Hygiene and Public Health, examined the potential impacts on health of "climate variability," and concluded that: "The levels of uncertainty preclude any definitive statement on the direction of potential future change. . . ." The report further states that "at present most of the U.S. population is protected against adverse health outcomes associated with weather and/or climate. . . ." The report was part of a congressionally mandated study of climate change in the United States, and the team of authors included experts from academia, government, and the private sector, who were selected by the U.S. Environmental Protection Agency's Global Change Research Program. The report is published in the April 2000 issue of *Environmental Health Perspectives*.

THE ONLY GOOD ARGUMENT YET PRESENTED AGAINST DDT

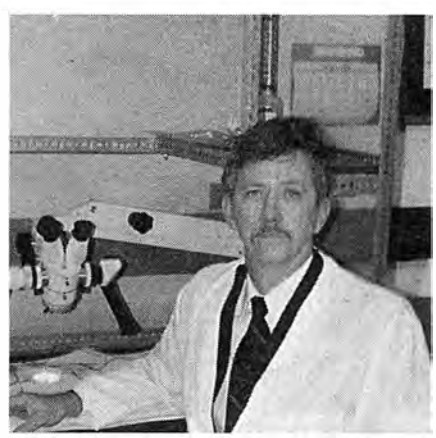
The letters column of *Invention & Technology* magazine (Spring 2000) prints the only good argument we have yet seen against DDT. We quote in full the letter, written by Shell Reinish of Westlake Village, Calif., under the heading "The Perils of Pesticide."

"Just as a point of information, in your article 'The Short-Lived Miracle of DDT' (by Darwin H. Stapleton, Winter 2000) there is a picture of Mrs. Gee Goldstein of Brooklyn spraying her Brooklyn apartment with Army DDT in 1945. The caption says, 'Her young son is present to demonstrate its safety.' [A small boy is pictured in a child's bed, while the mother sprays.]

"It may not have been so safe. That baby grew up to be the porn mogul Al Goldstein, publisher of the newspaper *Screw*."

NEURAL DEVICE MAY ALLOW PROSTHETICS TO FUNCTION NATURALLY

Animal models of a neural interface that links the nervous system to the electronic hardware of a prosthetic limb are under testing at the New York Institute of Technology, and testing of a human model is planned in the next three to five years. The device is being developed by Dr. Michael Wells, a professor of biomechanics and bioengineering at the Institute. It connects disrupted nerves in the amputated limb to small muscle segments, using electrodes that amplify control signals by a power of 10. The prosthetic device will then be able to carry out the brain's commands in a more natural manner. The research project is funded in part by the National Science Foundation.



New York Institute of Technology

Dr. Michael Wells, who is working on the development of a neural interface device to allow prosthetics to function naturally.

ELECTRIFICATION GREATEST 20TH CENTURY ENGINEERING PROJECT

Electrification topped the National Academy of Engineering's list of the 20 engineering achievements in the last century that had the greatest impact on the health, safety, productivity, and overall standard of living of people throughout the world

(Continued on page 12)

Letters

Continued from page 4

sphere (Reviewed by Paul Sheridan, Fall 1999, p. 67): You probably know that Thomas Gold published a theory of "abiogenesis" of oil in 1987 (*Power from the Earth*). He regarded petroleum as part of the makeup of the planetesimals that accreted to form the Earth. Gold's theory in 12 subsequent years in his publications, up to and including his contribution in December 1998 of a poster at a conference on Petroleum Potentials in the Crystalline Basement, held in Kazan, Tatarstan, never changed. The petroleum was of primordial origin.

The Tatarstan paper was titled "Metal Ores and Hydrocarbons," and its theme, in Gold's words, was that ". . . hydrocarbon flow, on the way up [from Earth's interior] will make a large array of molecules, in detail depending on such things as the carbon-hydrogen ratio, the ratio to other elements like nitrogen and oxygen, the catalytic action of specific minerals in the rocks, and the temperature-pressure regime it finds on the way." Thus, no mention is made by Gold to the end of 1998 or any reworking by biology of inorganic, abiogenically-originating, geologic product to create petroleum.

How Thomas Gold could undergo such a conversion between the end of the 1998 conference and the 1999 publication date of *Deep Hot Biosphere* is puzzling—unless one knows that next to Gold's paper in the Kazan conference was another paper that specifically advances an entirely new concept: the anhydride theory, whereby, petroleum is created by bacteria acting on methane that effuses from Earth's interior. The paper was mine: "Anhydride Theory: A New Theory of Petroleum and Coal Generation." It sets forth the proposition that petroleum is a mixture of "an-hydrides" of methane, and that these are created by the progressive stripping of hydrogen from methane by microorganisms, either with or without associated fossil biomass. Coal is a result of the bacterial addition of carbon that is derived from methane to peat.

The term shameless is a good description for Gold's blatant plagiarism of my theory.

C. Warren Hunt
Calgary, Alberta, Canada

Paul Sheridan Replies

Nowhere in *The Deep Hot Biosphere* does Dr. Thomas Gold proclaim that there is a direct conversion of geological materials into "petroleum" by biological means. Mr. Hunt does not offer the page reference that confirms his allegation.

Dr. Gold's earlier book, *Power from the Earth,* goes into great detail about the interaction between biology and deep-source hydrocarbons, but never does Gold "undergo such a conversion," as alleged by Hunt.

Mr. Hunt should read Chapter 9, of *Power from the Earth.*

News Briefs

Continued from page 11

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Astronaut Neil Armstrong, the first man to walk on the Moon, announces the top 20 engineering achievements of the 20th century, as selected by a blue-ribbon panel of U.S. engineers.

during the past century. The achievements were nominated by 29 professional engineering societies and ranked by a panel of the nation's most distinguished engineers.

Presenting the list Feb. 22, at the National Press Club, was former astronaut Neil Armstrong, a member of Academy and the first man to walk on the Moon. The panel noted that the impact of electrification has been vast, and a prerequisite for economic development and for most—if not all—of the other achievements on the list. Also in the top 10 were the automobile, the airplane, water supply and distribution, agricultural mechanization, and air-conditioning and refrigeration. As Armstrong read the list, he reported that space exploration was number 12 out of 20. He described space flight as "perhaps **the** greatest engineering achievement of the century," but said that it ranked behind the others in direct impact on the quality of life.

PRINCE CHARLES LAUNCHES ECOLOGICAL RESERVE—AND TROUBLE

England's Prince Charles visited the former British colony of Guyana Feb. 26-27, to inaugurate a 400,000 km ecological reserve on the border with Brazil. The new Iwokrama reserve is in the Guyanese region of Rupununi, which borders the Brazilian state of Roraima, and the Raposa/Serra do Sol area, 1.6 million hectares of which is slated to be demarcated as an Indian reserve by the Brazilian agency in charge of Indian affairs.

The visit set off alarm bells in Brazil, as indicated by coverage in the *Brasil Norte* newspaper, which notes that a leading non-governmental group supporting this demarcation is the British-run Worldwide Fund for Nature (WWF), "which has the Prince as its primary spokesman." The paper also points out that, as in the case of the Yanomami reserve, a cross-border indigenous region in both Venezuela and Brazil, the newly designated reserve "could become a free-transit area for the Macuxi Indians living in Brazil and in Guyana, despite the international border separating both countries."

Brazilian patriots have criticized the ecological reserve movement as a subterfuge for the destruction of national sovereignty and an aid to the looting of natural resources, including strategic minerals, by international conglomerates. (See this issue's Special Report, p. 13.)

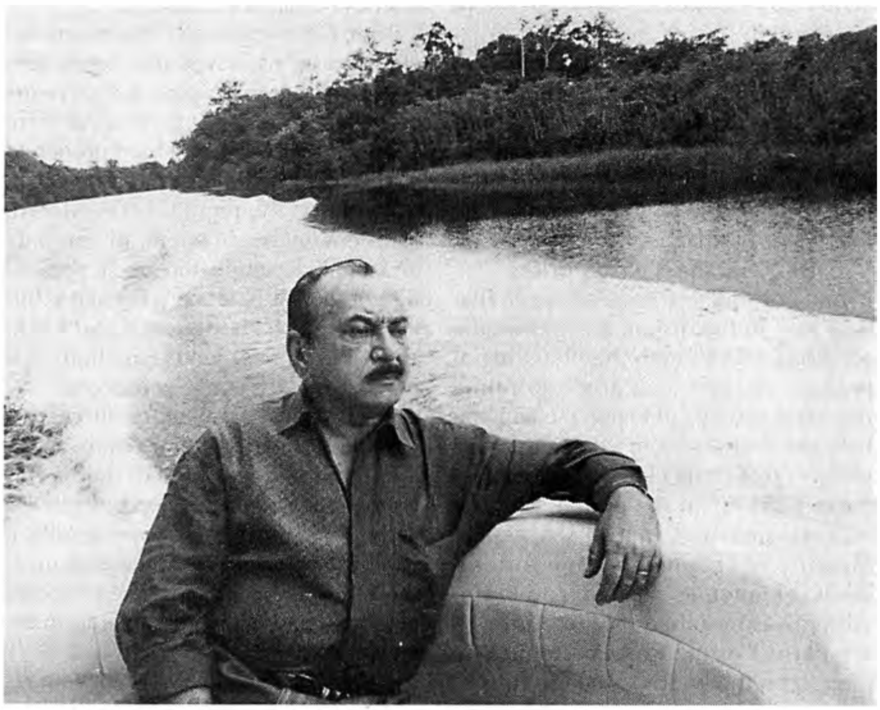
Develop the Amazon!

Brazilian Senator asks: 'Why should Brazilians go hungry to please the Queen of England?'

EDITOR'S NOTE

Brazilian patriots from all walks of life have launched a renewed campaign in defense of Brazil's right to develop the entirety of its national territory, including the Amazon. Campaigns carried out under the banner of environmentalism, "indigenous rights," and other frauds have already succeeded in banning most human activity throughout the enormous Amazon region, largely on the basis of lies and deliberate misinformation. The Brazilian government, headed by President Fernando Henrique Cardoso, has proven itself an eager instrument of the international interests running the campaigns of lies, in order to better grab the riches of the Amazon for themselves. (Cardoso, it should be noted, as President, kneeled before the Queen of England in 1997, in order to receive a British knighthood.)

On Nov. 10, 1999, the Brazilian Senate's National Defense and Foreign Relations Committee held extraordinary hearings on "The Amazon—Threatened Patrimony," chaired by former President Jose Sarney (now a Senator). One of the two speakers who testified was Senator Gilberto Mestrinho, who represents the state of Amazonas.



EIRNS

Sen. Gilberto Mestrinho, who represents Brazil's state of Amazonas: "My ecological standpoint is a profoundly Christian one, because I learned as a child . . . that Christ came to save man—I don't recall any chapter or verse which says that He came to save the trees and the crocodiles" (from a 1992 interview with Executive Intelligence Review).

Mestrinho, who served three terms as Governor of Amazonas before being elected to the Senate, is an outspoken defender of the proposition that the Amazon, like the rest of the Earth, is there for Man's development. Further, that the right to the benefits of progress extends to all human beings, and that Brazil's Indians, like all other Brazilians, are human beings.

Proud that his own grandmother was an Indian, Mestrinho has pointed out that if today's racist "protectors of the Indians" had dominated politics when he was growing up, he never could have become Governor. His remarks, taken from the official record of the Brazilian Senate, have been excerpted and translated from the Portuguese by Gretchen Small for 21st Century. *Subheads and footnotes have been added; translator's comments are in brackets.*

* * *

Excerpts from Speech of Sen. Gilberto Mestrinho, Amazonas

To better understand the Amazon, let us make a mental regression to the time in which we studied geography, and visualize, in a virtual image, the position of the Amazon on the map of Brazil, and its position in relation to the countries which border it. It is a vast area. The Brazilian Amazon covers 550 million hectares; there are 220 million hectares more in the bordering countries, which form what is known as the

"Amazon Shell." These are, precisely: the region of the Pando and the Beni in Bolivia, the Department of Loreto, in Peru, the Department of Amazonas in Colombia, the Department of Amazonas in the Venezuelan savannah, and the border areas of the Republic of Guyana, the Republic of Surinam, and French Guyana, the only one which still has not acquired the status of an independent country.

This region, which forms a border—in part delimited by rivers, in part by geodesic lines, some lakes—is greater than 6,000 kilometers long, separating the Brazilian part from the part of the countries which make up what is called the International Amazon.

How Did the Amazon Arise?

And how did that Amazon arise? That Amazon, in the distant past, formed a great sea which, with the first alluvial inundation from the Parima-Roraima mountain system, and later, the alluvion from the Andes—the most recent historically—created the greatest sedimentary basin existing on the planet. The sea was expelled, and, in its place, a great quantity of sediments came to form what is known as the Amazon Plain, which was bounded on the north, by the Parima or the Roraima mountain ranges; on the west, by the foothills of the Andes; and on the south and southeast, by the foothills of the central Brazil range, the central Brazil ridge.

In this region, with that alluvion of earth, the sedimentary basin alone, the alluvial strata, in some areas reaches a depth of more than 3 kilometers. At the beginning, this was a semi-desert region. According to the experts, it was a large savannah. . . .

At the time of the last glaciation, a little more than 10,000 years ago . . . the greatest concentration of carbon gas existent over the earth was located exactly over the Amazon. That concentration of carbon dioxide, through the conditions of climate, Sun, and humidity, transformed that carbon dioxide into a gas battery—which is what trees are. Trees are nothing more nor less than a carbon dioxide battery transformed into wood. From this came the great forest in the Amazon region.

So, the Amazon is the only region in the world—contradicting many theories—which was initially a semi-desert, or almost desert, and which became a forest, the largest forest also existent on the face of the Earth, the Amazon, which has 550 hectares in Brazil and 200 million hectares in neighboring countries . . . . In certain areas, the Amazon kept that original characteristic. For example, in the valley between Madeira and Purus, are the prairies of Puciari, 2.2 million hectares of grasslands . . . immense prairies typical of the region. . . .

That is the characteristic of the region: forests, natural prairies, and a fantastic hydrographic potential of rivers and lakes, capable of generating more energy than the total amount produced in the country, if all the hydroelectric potential of the region were utilized. [This energy is] sufficient, in a minute and a half, to supply the whole population of the Earth, when we reach 6 billion people, 150 liters of water each. The Amazon river sends 6 million liters of water into the ocean per second.

A Dazzling Array of Resources

And what exists in that Amazon? For a long time, it was argued that it was impossible for mineral deposits to exist in the Amazon, because, geologically, it was very new soil, a sedimentary area; therefore, there had not been enough time for the formation of minerals in the region.

However, not long ago, Man, with his creativity, invented the satellite, ultrasound technology, satellite depth-imaging, and was suddenly dazzled.

"When someone opts to give more importance to animals than to human beings, next, he will treat human beings as animals."

The world believed that there was no possibility that region possessed minerals in its bowels, and had even previously come up with the idea, without anyone protesting—except we of the Amazon, at the time—of flooding the Amazon forest, through the creation of a lake dreamed up by the Hudson Institute. The supposition, at that time, was also that the mineral deposits would be located in the foothills of the Andean and Parima ranges. It would be easier, flooding the forest, to bring transportation there. At the time, the world aplauded. . . .

That Amazon was then appraised by the analysts and researchers, as simply, the greatest mineral region on the Earth.[1] The mineral potential of the region was estimated at $6 trillion. And further, [there were] precious and strategic metals, such as gold, platinum, niobium, uranium, cassiterite, tantalum; in addition to other minerals of great economic value: iron, copper, titanium.

When that was discovered in the region, it coincided also with the discovery that, despite the fact that the Amazon forest was highly heterogeneous, there are more or less homogeneous areas: In Pará, for example, of mahogany; in Alto Solimões, mahogany; in the region of Alto Juruá, also cedar and mahogany.

Enter the Environmentalist Liars

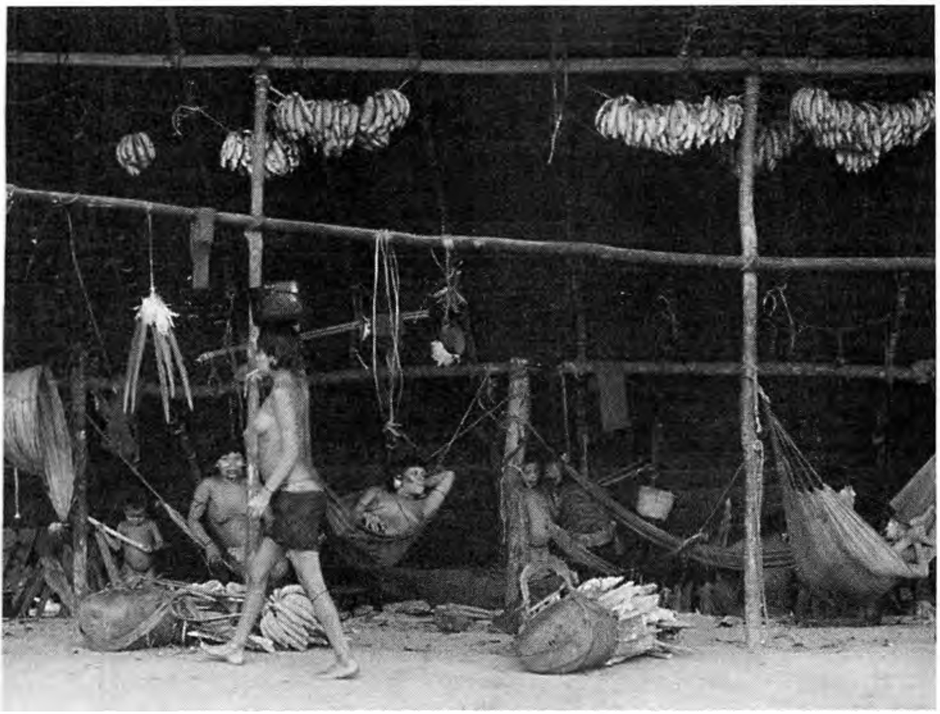
Well, with these two discoveries—mineral wealth and wealth of vegetation—the international markets were panic-stricken. It was necessary to stop, at any price and any cost, the development of the Amazon, and international protectors began to appear. A great many organizations assembled to protect the Amazon. . . .

And, suddenly, terrible incidents related to the Amazon began to be reported, especially after international aid programs for the region were drawn up. These organizations came here, and adopted the principle of brainwashing of the theoreticians of the Tavistock Institute:[2] the principle that it is necessary, in order to achieve its objectives, to poison the mind of society so that it believes unreal facts.

The campaigns began, all at the service of the Establishment, this Anglo-Dutch-French Establishment which exploits and dominates these markets, especially the world mineral and timber markets.

Those organizations came here, were set up here, and they did not develop any identification with Brazilian reality, nor with the environmental question, when they speak about the Amazon. Why? Because the most important natural resource existing on Earth is Man—this is the most important of all. The day in which we disappear, the Earth will have no importance. This is the proper view.

And Mankind with intelligence, with knowledge, is going to use the environment to its benefit. Because, when someone opts to give more importance



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"Keeping [the Amazon] untouched does not benefit anyone. The Indian remains miserable. I have seen it. It is painful." Here, Yanomami Indian tribesmen at their communal huts in the rainforest of Venezuela, bordering Brazil.

to animals than to human beings, next, he will treat human beings as animals. This is what Hitler did. He was the first head of state who founded environmental policy and protection of the animals, and the human beings who survived know what happened. . . .

It is these principles, almost all premised on fascist principles, which oriented that false environmental policy's obsession with the Amazon. There is no degradation of the Amazon. Francisco Orenalla descended the Amazon River in 1546; from 1546 until 1999, almost 500 years [have passed]. Yes, we made some mistakes in the region, instigated by those who today think differently—because the mistaken projects then carried out in the Amazon were inspired and financed by the World Bank, and the large landowners were foreign companies, not national ones. The projects in the Pará were all by Mercedes, Volkswagen, companies like that, in the south of Pará.[3]

Use Your Head!

That principle leads us to reflect upon and examine something: When you read news stories—and I am going to give you some concrete examples—about the deforestation of the Amazon or illegal timber taken from the Amazon, be careful. Make some calculations, reflect.

A few days ago, one of the most important newspapers in the country, a serious, thorough analyst of the economy, wrote the following: Last year, "40 million cubic meters of timber left the Amazon, of which only 20 percent was legal." And it added, that according to some, [this figure was] 28 million [cubic meters].

When you read a news story like that, for your clarification, do the following calculation: A ship, the largest ship which can negotiate the Amazonian rivers, is able to transport only 5,000 cubic meters of wood at a time. Therefore, to transport 40 million cubic meters, 8,000 ships per year would be necessary: [That is] 666.6 ships per month, 22.2 ships per day, 2.2 ships per hour, would make 40 million. If it were 28 million: 466 ships per month, 15.5 ships per day, and 1 ship every 90 minutes.

Imagine what would happen to the traffic on the Amazonian rivers if this were true. And the time to load the boats? How to load the boats? Where to load the boats? And the world market for all this timber? This is so that we see what the news reported is like. . . .

Once NASA, which is a most serious international institution, publicized on televisions around the world, the consequences of the deforestation of the Amazon, the burnings in the Amazon, and showed the prairies of Puciari. This was loudly publicized throughout the world. But, when she [NASA] saw the error and retracted the story, the retraction was released discretely and no one knew anything about it. . . .

Those are the news stories reported about the Amazon, raising that scandal and frightening people with alarming news of the Amazon's destruction. To give you an example, the whole Legal Amazon had, at the beginning of the century, 732,000 inhabitants. Today, it has 20 million. . . .

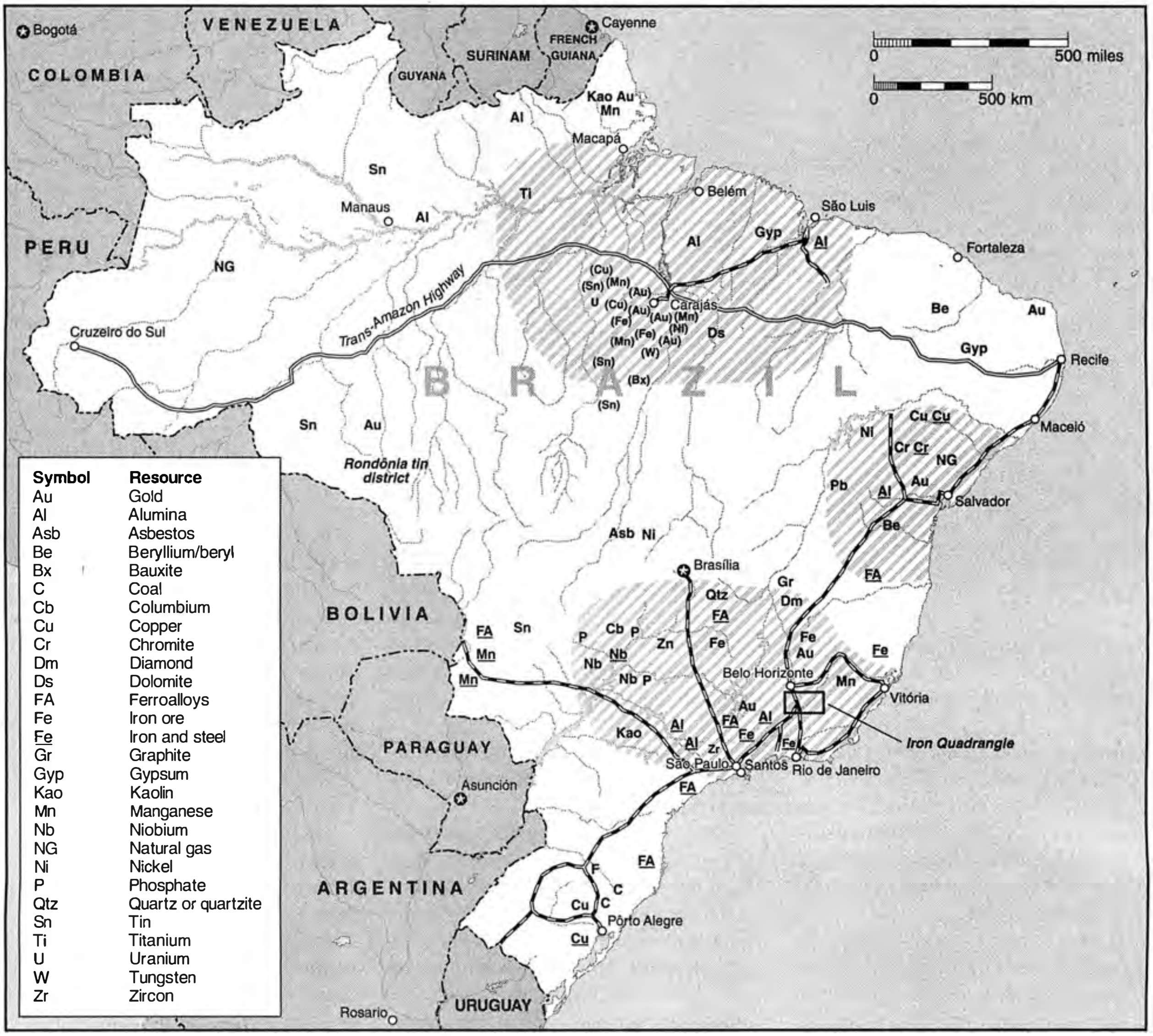
In my state [Amazonas], we had a bit more than 400,000 inhabitants in the decade of the 1940s; today, we have 3 million! Manaus, [the capital of Amazonas, and] cities and roads in the interior were built, and so on, and the deforestation does not even reach 2 percent of the original jungle. In the entire Amazon, not 11 percent of the original forest has been affected, despite the errors which occurred. . . .

Yet, every day, you can see the news, and, what is worse, the Brazilian government's environmental policy, totally contrary to the Amazon's interests, because its objective is not to attend to the desires of the Amazon population which lives there; its objective is to expel Man from the Amazon, creating conditions which make life impossible in the region.

Yanomamis As Pawns

And why is that? Because it is necessary to empty the Amazon; it is necessary that Brazilians leave the Amazon so that its domination or control is easier, which is what they are already achieving. And how? Besides environmental policy, there is the indigenist policy. . . .

A policy of occupying the Amazon border areas was adopted abroad, under the pretext of defending the Indian populations. There was a meeting in Britain, after the British observed our country and did a full survey of their interests, in which the necessity was discussed of imposing upon the Brazilian government—this discussion was carried out in the presence of the Queen, the Duke of Ed-



BRAZIL'S MINERAL WEALTH

Brazil has one of the world's largest reserves of mineral and natural resources. Half of its territory is located in the Amazon rainforest region, much of whose mineral-rich area remains unexplored, and its resources untapped.

The symbols on the map show where specific resources are being mined, and where there are beneficiation plants or wells. Symbols in parentheses indicate significant sites of undeveloped resources. Underlined symbols are where there is a processing plant or oil refinery, including smelters and metal refineries.

The hatched areas are where there are major holdings of the Companhia Vale do Rui Doce (CVRD), the formerly national government company, which the government privatized in May 1997. The CVRD is the world's largest producer of iron ore, and holds concessions on the largest and most promising areas of mineral exploitation in the country.

Source: *Executive Intelligence Review*

inburgh, and the British Minister of Foreign Relations—the demarcation of the Park, Yanomami Reserve.[4]

They discovered that these Indians had existed there for more than 20,000 years.

According to the Yanomamis, with whom I have lived . . . they wanted the demarcation of their lands, very justifiably. But the Yanomamis are four different groups. All of them are Yanomami, but they are different. They even speak different dialects, and live constantly fighting among themselves. The Yanomamis had as a custom—now they no longer do this—the killing of female babies who were born. There was, therefore, a great shortage of women, which even today still exists in the Yanomami villages. They fought to rob women from the other groups who had escaped that initial killing.

They wanted a demarcation. There are 150 settlements, called islands, or groups where the villages are located. Under the Sarney Government, the decrees had been drawn up to give 1,724 million hectares to the 150 settlements desired by the Yanomamis. They wanted this division. The Sarney Government carried out a study, and was going to do this demarcation.

But, while that interested the Indians, it did not interest their protectors. Whoever has heard speak of the Guyana Shield, knows that this is a region hungered after for a long time. It extends from the Orinoco, Casiquiare, and Rio Negro rivers to the Atlantic, and is extremely rich in minerals. [See figure, page 18.]

The linking of the Casiquiare and Orinoco rivers offers the opportunity of linking navigation flows of great interest to the country, an outlet for Brazilian production. So, it was necessary to make the demarcation cover continuous areas. Claudia Andujar, a Swede at the service of those organizations, and of the British headquarters which dominates the minerals market, drew up a blueprint of all the area where precious metals are located, and which should be delimited as a reserve.

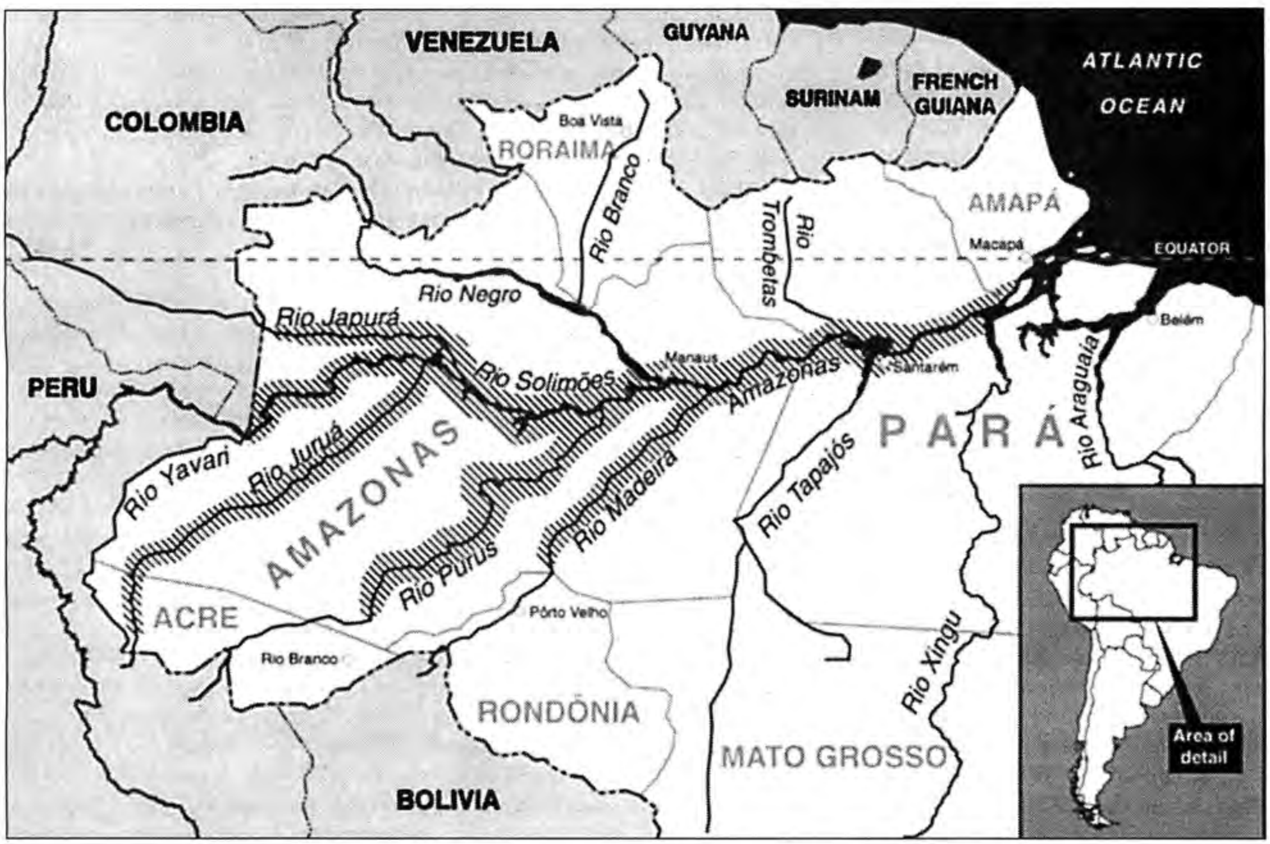
There was a first meeting in London, a second one in Brazil, and, at the third, in 1990 or 1991, the Brazilian Government, through the President of the Republic, signed the demarcation of 9.2 million hectares of lands for the 4,000 Yanomamis who live in that area along the border between Brazil and Venezuela. The same thing [was also] obtained from the Venezuelan Government of Carlos Andrés Pérez, through the biosphere reserve in the Yanomami area of the Orinoco-Casiquiari region of Venezuela.

Bankers' 'Nations' Created

The future Yanomami nation, so-called, was ready. Only, the Indians did not want that. . . .

So, let us visualize our initial image: Continuing along the border of Venezuela, Colombia begins. A new reserve of 8.2 million hectares. There, it was discovered that there were Tucano Indians, nearly 18,000, almost all illiterate. . . .

Still, the encirclement of the borders was not finished; it was necessary to close off the lower part. Thus, they be-



THE AMAZON RIVER FLOOD PLAINS: A HUGE AGRICULTURAL POTENTIAL

Senator Mestrinho estimates that the Amazon could be a home to 50 million people, if scientific flood plain agriculture were employed. The Amazon River fluctuates between 8 and 10 meters, which allows large areas to be flooded for approximately six months of the year. The floodplains that form when the Amazon and its tributaries overflow are extremely fertile, and available for cultivation for the other six months each year.

The approximate area of the fertile floodplains is estimated at 180,000 square kilometers (44.5 million acres). About 80 percent of these floodplains are in the state of Amazonas, which Senator Mestrinho represents. To develop this huge potential requires the appropriate technology—special wide-wheel tractors, for example—and scientific research to determine the best types of crops and seeds.

gan to consider the Javari reserve. No more than 600 Indians live in the Javari reserve, 8 million hectares on the Brazilian side. These are the Caceteiros or Curubas Indians, who live in Brazil in the dry [low water] season, and another part of the time in Peru.

But that is the cradle of future nations. I saw already in Europe, a map of Brazil in which the Yanomami nation is depicted as if it were a different nation, another nation. It is known that Indian leaders are studying in international universities, preparing themselves to be the future leaders of those so-called nations. They believe that they can do in Brazil what has been done to Africa. . . .

All these reserves were created in the region. And more than that, bordering on the reserves, the Brazilian Government created the so-called national parks and ecological reserves. And now they want to create the so-called—this also was dictated by the World Bank and the Group of Seven—"ecological corridors." They did not even take into account the surface area, in as much as, for example, in my State, the Amazonas, five ecological corridors are envisioned. These corridors would be 140 kilometers long, with neighboring areas protected also. In those ecological corridors, nothing can be done.

Then, calculate that five times 140 is 700 kilometers. Yet, in the Amazonas, some regions are not more than 800 kilometers long, from north to south. So, how can anyone live there, if everything is prohibited? . . .

The NGO Army

What props this up? The so-called nongovernmental organizations (NGOs). There are good NGOs, which do work, but almost all of those who say they are dedicated to the environmental or the Indian question, defend other interests which are not the interests of Brazil, are not the Amazon's interests, are not the interests of our people, because none of them propose a way to generate employment. . . .

Do they produce bread for anyone? Generate any economic activity? Better the quality of life of the people? No. This, unfortunately, is the painful reality.

And there are an enormous number of organizations which work in the Amazon. . . . A book was published, recently, discussing these organizations. . . . There are 320 organizations looking after the Amazon. Three hundred and twenty organizations, speaking of NGOs, dealing with the Amazon. And they carried out that campaign of stickers, [which read] "Burn a Brazilian and Save the Amazon!". . .

Earth Created for Man

God, when he made the world—all religions teach this—made Man and the environment, so that Man, with the sweat of his brow, draws his sustenance, and that of his family, from the environment. This is a Christian principle. He conceived the world to save Man, according to the teachings of all the religious books. Every prophet, of whatever religion, conceives of the world to save Man, who is what is most important on Earth.

Have you, gentlemen, ever thought, that our surface area is 550 million hectares, of which 369 million hectares are covered with forests?—A country like Finland, in the Amazon, would be a large backyard because of its small size, replete with lakes.—That we, with this immensity of timber and forests, practically do not participate in the international market? Not even 500 million U.S. dollars' worth of forest products are exported from the region. Finland, in forest products alone, exports more than $10 billion a year from a forest which is frozen six months a year, and where a pinetree takes 80 years to grow.

[In contrast], the *samauma miratinga*, the *virola*, in the Amazon plain, produce, in 10 years, at least 8 cubic meters of wood [each], and the timber of the region could be taken advantage of without any environmental damage.

I am going to give but one example: For 50 years, all the energy generated in the Amazon—for electricity, for pumping water, for urban transport— . . . was taken from the forest. There were many boats which went up and down the river, creating a great river traffic at that time, and all the energy was taken from the forest. It was firewood, which was taken from the forest. It was the era of the steam engine.

I remember, when I was a boy, I wandered on the boats, and there were ports for firewood, where the boats would stop to pick up firewood. They would go a bit further, and, once again,

THE 'GUYANA SHIELD' INITIATIVE

The "Guyana Shield" Initiative mentioned by Senator Mestrinho is financed and controlled by the World Wide Fund for Nature (WWF) and its sister organization, the International Union for the Conservation of Nature (IUCN), with other NGO participation. Its alleged objective is to "protect" the flora and fauna of the Shield area.

This geographical area, which encompasses the area known as the Guyana Island, the area delimited by the Orinoco, Casiquiare, Negro, and Amazon rivers, has historically been the geopolitical target of the Anglo-French-Dutch oligarchy, as the preferred entry point for establishing a foothold in the Amazon. (This objective was partially achieved with the establishment of their respective colonies—the French, Dutch, and British Guyanas.)

At the center of the "Shield" is the state of Roraima, which, as a result of the NGO activities, now has 44 percent of its territory either in Indian reserves or nature conservation areas—and therefore unable to be developed.

stop to pick up firewood. But, if we try today to find where this firewood was taken from the forest, we find no sign of it. Why? Because the forest renovates itself. . . .

So, my friends, if we wish to effectively carry out a policy of improving the atmosphere in carbon dioxide, CO_2, conserving and improving the Amazon jungle, giving better conditions of life to those people, the best way would be by managing the forest. First of all, because Man, cutting wood, betters his quality of life; second, because, cutting down an old tree, a new tree is born, which will absorb more CO_2 from the atmosphere, creating a cycle of improvement of the environment and of wealth for Man.

That would be the correct philosophy to apply in the region. The scientific and technical knowledge for this exists today. If the Brazilian government, if the nongovernmental organizations, really wished to contribute to the development of the region, they would take this suggestion, this idea, this work, this teaching, and not accost us with accusations such as, "you are destroyers", "you are amateurs," "I'm going to close this sawmill, I am going to close this, that."

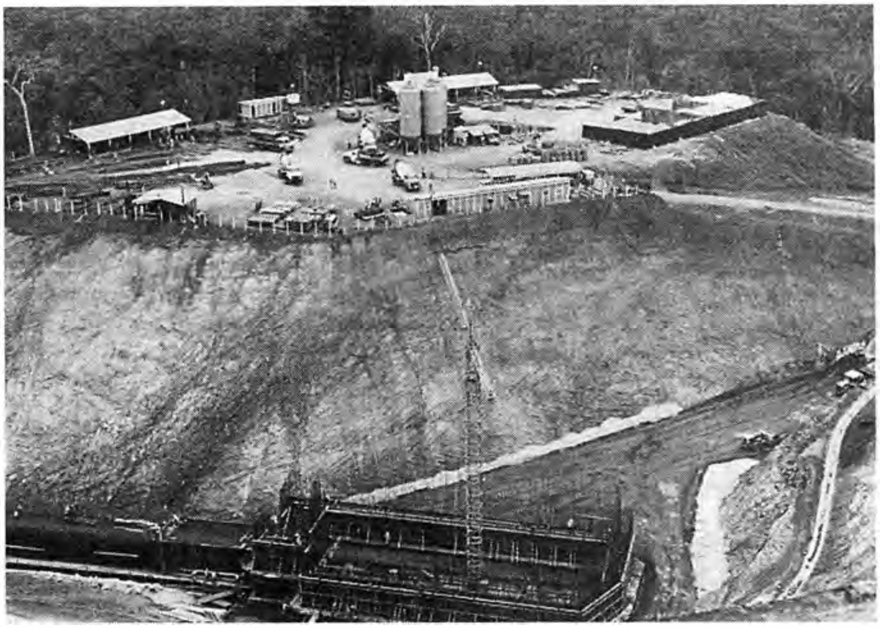
From what are men going to live? How are they going to feed their children? In exchange for what? To please the Queen of England? To please the Duke of Edinburgh? No, not that!

It's Man That Is Endangered

I know that there are people who think that I am an enemy of the ecologists and the environmentalists, but I have never been so. . . . I am opposed to farces, to disinformation, the other interests behind the environmental or indigenist policy. . . . I distrust those who come here to save trees. They are not endangered. It is Man who is endangered in the Amazon, with this government's erroneous policy and international pressure.

The animals of the Amazon are not endangered; it is the poor Brazilian Indian who lives there, obstinately keeping the region within the national territory, who is endangered. . . .

As for rubber . . . [even] producing with all our might, if there were still rubber-tappers in the Amazon, we would only preserve misery. . . . This is an activity of misery. We do not want to preserve misery in the Amazon; we want development.



EIRNS

The Grande Carajás Project: The Carajás iron mine, which is in the middle of the Amazon rain forest, in hills 2,000 feet above sea level, has an estimated 18 billion tons of iron ore, with an average purity more than twice that of most U.S. iron mines. Initial plans called for an agro-industrial city of 20,000 people, but the dictates of the international banking groups turned the project into one of raw materials export only.

As for extractive reserves,[5] they are are a romantic dream: very pretty, but they preserve misery. If seeing pitiful, poor, miserable, children with distended bellies is beautiful, you defend that activity. But we do not want that! No!. . .

Keeping [the Amazon] untouched does not benefit anyone. The Indian remains miserable. I have seen it. It is painful. . . . I saw, a month ago, an Indian chief, and three Yanomami tribal leaders of different ages because they were from different groups. . . . They told me: [the women] walk six hours from the hut to the mountain to look for bananas. Six hours to get there, without stopping, and six hours to return. So, they have to go on one day, sleep there, and then return.

The women can't stand this any longer: [walking] kilometers with that immense weight, and sometimes with a child to carry. The Indian doesn't want that anymore. He cannot tolerate that any more. It is inhuman, and unjust. . . . Bring the Indian real support, the benefits of civilization, respecting certain of his customs. . . .

Why do we not have the right to exploit, with much more intelligence, with much more rationality, with much more technology, those resources which we have, and to better the conditions of life of our people? . . . This is what our position should be. Thank you.

Notes

1. See "Oligarchy Wants to Grab the Amazon," in *Executive Intelligence Review*'s Jan. 22, 1993 feature on "The Real Amazon: Why Brazil Will Defend It." Also, "London's Policy of 'Africanization': The Next Target Is Brazil," and "British Cartels Break Up Brazil's CVRD, Target Continent's Raw Materials," in in "The True Story Behind the Fall of the House of Windsor," *Executive Intelligence Review Special Report*, Sept. 1997.
2. See "Tavistock's Imperial Brainwashing Project" by L. Wolfe, a report on the Tavistock Institute's brainwashing plan to control the world via "the empires of the mind," in "The True Story Behind the Fall of the House of Windsor," *Executive Intelligence Review Special Report*, Sept. 1997.
3. Such errors include an attempt (which failed) by foreign interests to establish a meat-producing center for export to Europe in Pará, when meat was already scarce in that area, and the World Bank-financed project in the 1970s, to send poor peasants to colonize the states of Rondônia and Acre.
4. *Executive Intelligence Review* published a chronology of the British Crown's 25-year project to set up the Yanomami reserve, "The Yanomamis: The British Royal Family's Personal 'Noble Savages,'" in the Nov. 11, 1994 issue.
5. The so-called "extractive reserves" promoted by the environmentalists and indigenists, would "permit" native populations to live within conservation areas, provided that they employ only the most primitive technologies, such as rubber tapping, harvesting nuts, and so on.

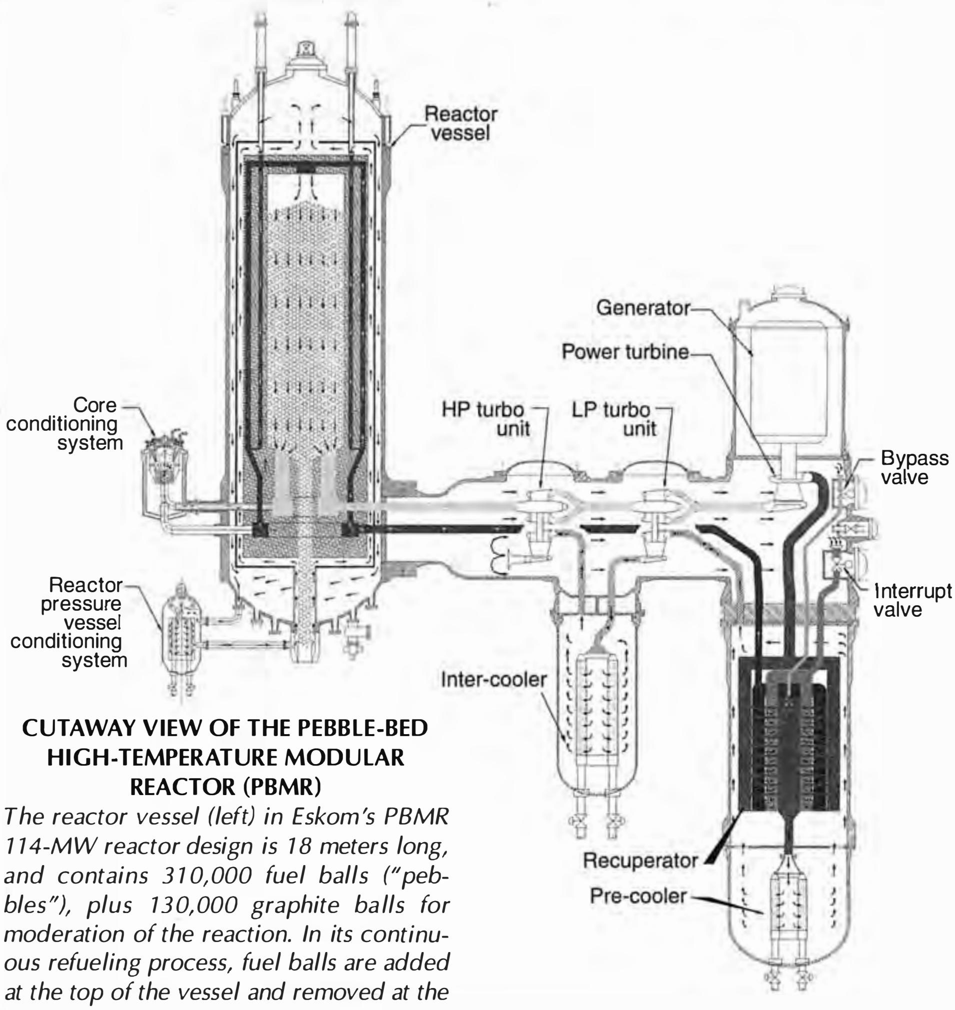
South Africa Plans to Mass Produce Pebble-Bed HTR Nuclear Reactors

by Jonathan Tennenbaum

South Africa's electricity company, Eskom, has drawn up plans for an ambitious program to develop and produce small, standardized, high-temperature nuclear reactor modules both for domestic use and for export. The detailed design is projected to be completed around the end of this year, with the first module to go into operation by the year 2005. Eventually, Eskom intends to produce as many as 30 modules per year, both for domestic use and export.

The South African project was begun during the early 1990s, to pursue the possibility of applying the technology of the High-Temperature Gas-Cooled Reactor, HTR, as a nuclear alternative to coal power in meeting the country's rapidly expanding electricity requirements.[1]

The project has special importance because the modular HTR has unique features that make it ideal for use as a power source for economic development around the world, and particularly in the developing sector. These include small size, low cost and high efficiency; robust and inherently safe design; sim-



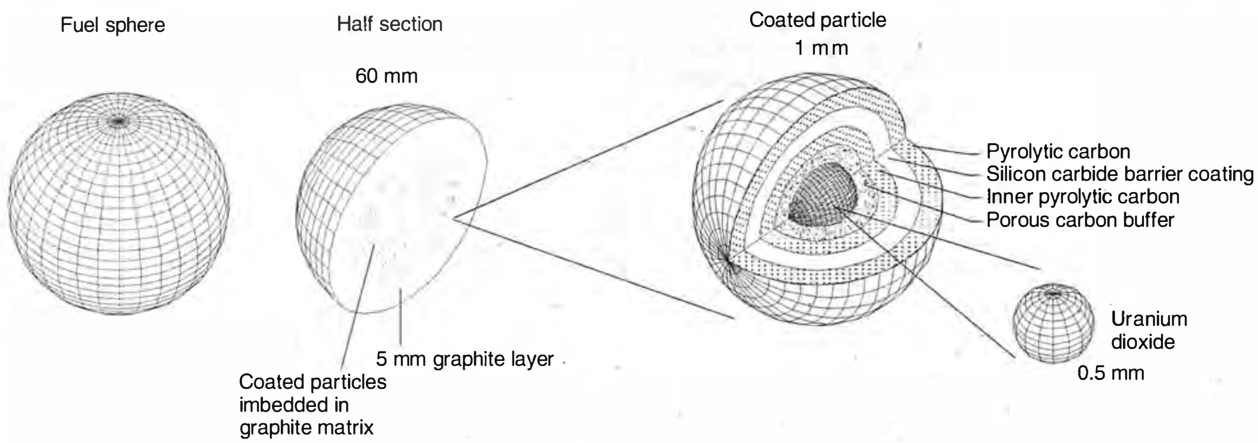
CUTAWAY VIEW OF THE PEBBLE-BED HIGH-TEMPERATURE MODULAR REACTOR (PBMR)

The reactor vessel (left) in Eskom's PBMR 114-MW reactor design is 18 meters long, and contains 310,000 fuel balls ("pebbles"), plus 130,000 graphite balls for moderation of the reaction. In its continuous refueling process, fuel balls are added at the top of the vessel and removed at the funnel-shaped reactor bottom. Each fuel ball contains about 9 grams of uranium.

Electricity is generated by a direct-cycle helium turbine (right). Helium gas is heated in the reactor core to 900°C, and passes directly to the turbine, where its thermal expansion is transformed into rotational motion for electricity generation. The expanded helium is recycled into the reactor core by two turbocompressors (center).

The small size, simplicity, and efficiency of the PBMR are what promises to make it the "work horse reactor" for widespread use around the word in the next 20 years.

Source: Courtesy of Eskom



PEBBLE-BED FUEL PELLETS

The fuel pellets for the PBMR are coated particles (pioneered by General Atomics in the United States). Each fuel pellet has uranium dioxide at the center, surrounded by several concentric layers of temperature-resistant materials, including silicon carbide. The coatings "contain" the fission reaction of the uranium, even at very high temperatures. Thousands of these particles are embedded in a graphite matrix, to make up a tennis-ball-size sphere. In the pebble-bed design, the fuel balls fill the reactor vessel. (In the General Atomics HTR design, the fuel particles are formed into a rod-shaped graphite matrix.)

Source: Courtesy of Eskom

plicity of operation; and potential application as a heat source for desalination, chemical industry and other industrial processes. as well as cheap generation of electricity. For this reason, the HTR figures prominently in the "Eurasian Landbridge" development concept promoted by Lyndon LaRouche and his collaborators.[2]

Although the basic HTR design employed in the South African project is the so-called pebble-bed reactor developed in Germany, the South Africans are not simply taking over existing technology, but are carrying out ambitious new technological developments of their own. This includes development of a helium turbine for direct-cycle generation of electricity. In fact, the South African HTR project is an excellent means to make highly productive use of the highly qualified scientific and technical manpower and industrial infrastructure, which already exists in that nation. In addition, as a developing country itself, South Africa is in an excellent position to act as a springboard for the HTR technology to the entire developing sector.

South Africa's Requirements

South Africa currently accounts for more than half of the electricity consumed on the entire African continent. Thanks to a major electrification program, according to Eskom, access to electricity has risen from only 30 percent of the South African population in the early 1990s, to more than 60 percent today. At present, more than 93 percent of South Africa's electricity comes from coal, and is produced mainly by large-scale coal-burning plants built near two large coal fields. These are located far inland, in the northeast of the country, far away from the coastal centers of electricity consumption. The prospect of avoiding the enormous costs of transporting large amounts of coal, or of electricity, over distances of 1,000 kilometers, is a major factor favoring the use of nuclear energy.

South Africa, which is rich in uranium, has a single pressurized water reactor, located near Capetown, which produces 4.5 percent of the country's electricity. However, for various reasons, Eskom has decided against constructing more large-scale nuclear plants, and instead has pursued the concept of much smaller sized modular reactors, based on Germany's pebble-bed HTR technology. The term pebble-bed derives from the fact, that the reactor core in this reactor type consists of a pile of spherical fuel elements ("pebbles"), about the size of tennis balls, instead of the familiar fuel rods of standard light water reactors. Accordingly, the South Africans call their new reactor the Pebble-Bed Modular Reactor or PMBR.

Background of the HTR

The HTR, or HTGR, is an alternative line of nuclear reactor technology, which differs in important respects from the light water reactor (LWR) and heavy water reactor (HWR) technologies, which are used in nearly all commercial nuclear power generation in the world today. Early experience included the Dragon reactor in Great Britain, the Peach Bottom, and Ft. St. Vrain reactors in the United States, and the AVR Reactor in Jülich, Germany.

The AVR reactor demonstrated the pebble bed concept invented by the late Prof. Rudolf Schulten. It operated successfully from 1967 to 1988, at outlet temperatures of 900° to 950° (compared to typical outlet temperatures of 280°-to 330° in LWR reactors). Development work on the Jülich reactor demonstrated not only the feasibility of "inherently safe" operation (see below), but also the potential to use the HTR as a heat-source for a variety of industrial processes, such as generation of synthesis gas, coal gasification, and produc-

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The author (third from left), visiting the Chinese research center that is testing technologies for the HTR at Qinghua University, near Beijing.

tion of synthetic fuels, including hydrogen; oil refining and heavy oil recovery; bauxite processing; ammonia production; desalination; and cogeneration of district heat.

In the mid-1980s, a large-scale, 500-MW HTR power plant was operated for several years in Germany, only to be shut down for political reasons. Significant development work continued, however, both in Germany and in the United States, where the HTR technology was pioneered by the General Atomics Company in San Diego.

Despite the remarkable successes of the Jülich HTR, in particular, HTR technology has so far failed to establish itself in commercial power generation. Apart from various technical hurdles, which largely have been overcome, the "back-seat" status of the HTR is not least of all connected to the opposition of sections of the nuclear power industry, which fear competition to the established LWR technology, and, generally, to the efforts of the anti-nuclear lobby. During the 1990s, however, the prospects for HTR technology have dramatically improved, thanks to a wave of new projects in several countries:

(1) A 10-megawatt-thermal (MWt) experimental HTR module, based on the German pebble-bed concept, has been built in China by Qinghua University's Institute of Nuclear Energy Technology near Beijing. This reactor is scheduled to go critical later this year.

(2) A 30-MWt High Temperature Test Reactor, built by the Japan Atomic Energy Research Institute (JAERI), is now operating at JAERI's Oarai Research Establishment. This reactor, which has prism-shaped fuel blocks, will be used (among other things) to test HTR process-heat applications.

(3) A cooperative program is now ongoing with General Atomics, France's Framatome, Japan's Fuji Electric Company and the Russian Minatom, to develop a 600-MWt modular plant, which would be used to burn up weapons plutonium and produce cheap electricity at the same time.

(4) Last but not least, is the ambitious PBMR program launched by South Africa's Eskom, which promises a near-term breakthrough of the HTR technology into commercial electricity production.

The Eskom PBMR Concept

A key feature of Eskom's strategy is the flexible use of small (110-MWe), series-produced, modular reactor units, rather than the giant (1,000-MWe or more) reactor blocks commonly used in commercial LWR and HWR nuclear power stations. To reach higher powers, Eskom plans to install as many as 10 HTR modules at a single site, with a common control room.

This approach replaces the economy of scale—individual reactors of very large capacity—exploited until now by the nuclear industry, by the economy of mass-production of a large number of standardized smaller units. A big additional advantage, especially for developing-sector countries, which should become a major export market for South Africa's new HTR industry, is the flexibility inherent in the low cost and small size of the individual modules. Thereby, the intrinsic advantages of nuclear energy will become available to nations and regions having limited long-term capital, and where existing electricity grids are far too small for the huge LWR plants built in industrial countries.

With the modular HTR system, a power station could be set up initially with just one or a few modules; additional modules would then be added, gradually, as the grid capacity and electricity demand grow.

Small size and standardized design will permit greatly reduced construction times. Once routine production has been established, it is anticipated that the lead time from decision to commissioning of a reactor will be only three years, including a two-year construction phase. (Naturally, construction and installation of multiple modules can be carried out in parallel.)

Eskom expects to reach a production level of about 30 HTR units per year by the end of this decade, of which 10 would be destined for domestic use, and 20 for export. Eskom counts mainland China and Taiwan, South Korea, India, and other Asian nations among the most promising potential buyers of the HTR modules.

The Cost Savings

The development costs for the first reactor units are estimated to be about $72 million. The construction cost for the first unit should be about $100 million, with the unit price subsequently going down to about $90 million for each of the next 10 units.

Taking account of the economies

achieved by series production of standardized HTR modules, it is estimated that the total cost of generated electricity can be brought down to below *1.6 cents per kilowatt-hour*—a very competitive level, indeed!

This remarkably low figure, which would make PBMR-produced electricity considerably cheaper than existing nuclear or fossil-fuel plants, has raised some eyebrows in the international power business, particularly among those not familiar with the unique advantages of this type of reactor. But the Eskom estimates have a solid basis.

By far the most significant cost-reduction factor—and a very substantial one, indeed—derives from the *inherent, passive safety characteristics* designed into the PBMR system: The complex, extremely costly active safety systems, which are needed to guarantee the safety of conventional nuclear reactors, are rendered superfluous by the natural physical properties of the PBMR, which rule out a dangerous overheating or release of radioactivity under all conditions (see below).

Second, because of their neutronic characteristics, the PBMRs have a very high burn-up ratio, permitting extremely cost-effective utilization of the nuclear fuel. Additional cost-reduction factors include, of course, the savings in construction time and expense by manufacturing many standardized units.

Although Eskom is taking on the lion's share of development work on the PBMR, the company will also be able to profit from a high level of international cooperation and participation. In addition to a long-standing cooperation with Germany, where the pebble-bed technology originated, the South Africans are cooperating, among others, with Russia's Kurchatov Institute (where a test core for the fuel elements has been set up), with the United Kingdom's AEA, with NRG in Holland, and with the Chinese HTR group at INET.

Benefits for Industry

The PBMR project can have considerable benefits for South Africa's domestic industry. The PBMRs built for South African domestic use, for example, will have 81 percent local (South African) content. For exported PBMRs, it is estimated that the stations will have 50 percent South African content.

Although electricity production is the first priority for Eskom, the inherent flexibility of the system recommends it also for other applications. For example, South African experts have pointed to the fact, the PBMR could lend itself particularly well as a heat source for desalination, by exploiting its waste heat temperature of up to 90°C. Negotiations have reportedly already have been initiated, on this theme, with the International Atomic Energy Agency and African countries such as Morocco.

Also, the ability to locate PBMRs virtually anywhere (once licenses have been issued), means that this reactor could become readily available as an industrial energy source for production of synthetic fuels, chemical products etc. The PBMR is also seen as a viable source of energy supply in remote areas, such as for mining regions located far away from existing transmission lines.

Pebble-bed Technology Basics

The German High Temperature Reactor (HTR) development group very early adopted the goal, to create "from scratch" (that is, not as an adaptation of a pre-existing design) a basic reactor type which could be not only *inherently safe,* but also highly economical. The idea was to realize a form of nuclear energy that not only would be good for generating electricity, but also could be used as a heat source for a wide range of chemical and other industrial processes; a reactor which could be realized in a variety of sizes and would be simple, robust, and safe enough to be built and operated in industrial and population centers anywhere in the world, including the developing nations.

The result, reached in decades of work, is the German pebble-bed HTR; and two related designs with somewhat different, "prism-shaped" fuel elements, developed in the United States and Japan.

Key to many of the inherent safety and many other advantages of these reactors is a U.S. invention called "coated particles." Instead of arranging the uranium fuel in the form of cylindrical pellets stacked inside metallic rods (fuel rods), the HTR fuel elements are built from tiny, sand-corn-sized uranium particles, which are encapsulated in concentric layers of temperature-resistant materials, including, especially, silicon carbide. A major advantage of these coated particles, is that nearly all the radioactive fission products, which are created by the fission of the uranium in the particle, remain trapped inside the particle, even at very high temperatures.

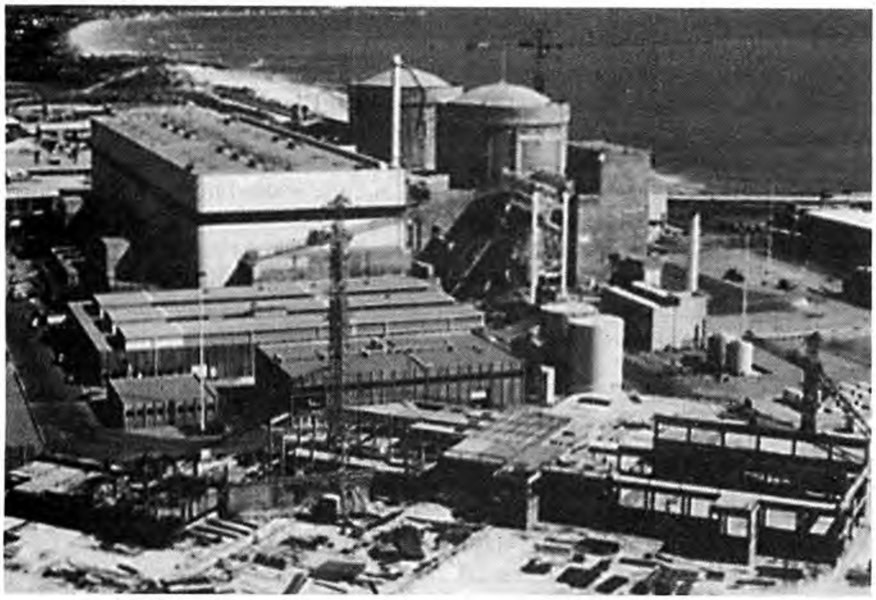
In the German pebble-bed design, the actual fuel elements are spheres ("pebbles") the size of tennis-balls, in which thousands of coated particles are embedded in a graphite matrix. If desired, further outside coatings can be added to the fuel pebbles, reducing diffusion even more, and rendering the pebbles impervious to oxidation and corrosion. (The latter is also relevant for the option, as pointed out by Prof. Schulten, for using *water* instead of helium as a coolant for lower-temperature pebble-bed reactors.)

The core of a pebble-bed reactor consists of a pile of hundreds of thousands of spherical fuel elements, filling a cylindrical vessel with a funnel-shaped conical lower end. In full operation, each fuel "pebble" typically generates around 500 watts of heat. Unlike the large light water reactors, which have to be shut down for several weeks for refueling, the pebble-bed HTR is *continuously refueled:* Fuel balls are withdrawn at the end of the "funnel" at the bottom of the reactor, and replacement balls are introduced at the top.

By this combination of introducing fresh balls and recycling partially "burnt" old ones, the reactivity of the core is maintained at a relatively constant level—generally speaking, only as is required to maintain the chain reaction.

The South African PBMR, with an 18-meter-long pressure vessel, is planned to operate with approximately 300,000 fuel balls, plus an additional 130,000 graphite balls for additional moderation of the reaction. In the course of the continuous refueling, a total of 10 to 15 fuel loads will be consumed during the design lifetime of the reactor. The level of enrichment of the uranium fuel will be initially 4 percent at startup, and then 8 percent for equilibrium operation. Each fuel ball will contain about 9 grams of uranium.

Because the fuel balls are not built into housings, there is no possibility of distorting, or jamming, inside the reactor—a potential problem for the fuel rod assemblies of conventional reactors. The control rods do not go through the



Eskom

South Africa's Koeberg Nuclear Power Plant, built by the French company Framatome, has two conventional 922-MW reactors that have been in commercial operation since 1984 and 1985. Nuclear now supplies 4.5 percent of South Africa's electricity.

core, but are located in channels surrounding it.

Through continual testing and development, the release of radioactive products from HTR fuel elements was brought down to *extremely* low levels—far lower than LWRs in normal operation at much lower temperatures. The encapsulation of radioactive fission products within the HTR fuel elements is ensured up to temperatures of 1,600°. Thus, HTR fuel elements can easily withstand temperatures at which the normal metallic fuels rods of LWRs would weaken and fail, releasing large amounts of radioactive substances.

The level of radioactivity released to the coolant gas (helium) in the 500-MW pebble-bed reactor in Schmeehausen, Germany, for example was so low, that a person could theoretically *inhale* it without risking dangerous radioactive exposure. This translates into much lower radiation doses to the personnel, than in conventional nuclear power plants (where doses are already very low).

In fact, the "cleanness" of HTRs can now be improved even further, thanks to a breakthrough by Prof. Schulten and his co-workers, in creating the advanced silicon-carbide-based ceramic material "Siamant." With the help of Siamant, it becomes feasible to construct fuel "pebbles" in such a way, that essentially *no* reactivity is released—up to temperatures in excess of the maximum temperature which could be reached in any conceivable accident, error, or even a deliberate mishandling of the reactor. Together with the smaller "pebble bed" HTR project in China, the South Africa PBMR can provide an invaluable test bed for further improvements of the spherical fuel elements.

The drastic reduction of radioactivity release from fuel elements under all conditions permits major simplifications in the design and maintenance of pebble-bed HTR reactors. In particular, the option of direct-cycle generation of electricity—by placing a turbine directly in the reactor cooling cycles—becomes far simpler, than is realized, for example, in the standard boiling water reactors, where significant levels of radioactivity in the coolant water necessitate special measures for containment and maintenance.

The Helium Turbine

The South African PBMR will include a major innovation vis-à-vis earlier HTR designs: exploitation of direct-cycle generation of electricity by a helium turbine—its first use in commercial power production. Here, the South Africans will make use of some of their experience in aircraft technology, and in the ultracentrifuge-bearing technology developed in the country's former military nuclear program.

The small size and simplicity of the helium turbine add to the attractiveness of the PBMR. The helium turbine has many advantages. It is much more efficient than a steam-cycle turbine; helium has an excellent heat transfer capacity, which leads to high thermal efficiencies. Second, the speed of sound in helium is five times higher than it is in air, which translates into the possibility of higher rotational speeds, permitting the turbine units to be made much smaller and more compact. A third advantage is that helium is chemically and radiologically inert.

The PBMR operates with a single helium gas coolant cycle, without the costly heat exchangers and secondary cycles used in ordinary light water reactors. Helium gas is heated in the reactor core to a temperature of 900°, and passes directly to a turbine, where its thermal expansion is transformed into rotational motion for electricity generation. The expanded helium is then recycled into the reactor core by means of two turbocompressors, entering at an inlet temperature of 569°. With its higher operating temperature, the South African HTR realizes a net efficiency of 45 percent (compared to 30 to 35 percent for standard LWRs).

Waste heat can be removed either by water cooling or air cooling, thus providing important additional flexibility in the choice of sites. (Use of air cooling was demonstrated on the 500-MW HTR in Germany.)

Achieving 'Inherent Safety'

A very important feature of the South African PBMR is its inherent safety, which at the same time permits unique economies in construction and operation. To appreciate the significance of this feature, one must take a brief look at the two different, basic approaches to the nuclear safety problem, which have emerged in the course of development of nuclear energy.

The main approach, which has been followed in the development and design of nearly all the commercial reactors operating around the world, is to reduce the estimated probability of an accident involving a dangerous release of radioactivity to the outside, to such a low level, that it is judged "acceptable" or even practically *insignificant* in comparison with the countless other risks of industrial society, and the average risks which any reasonable person accepts in his daily life.

According to this approach, the designers do not attempt to completely *eliminate* the possibility of a major accident—indeed, this is nearly impossible with the LWR technology—but only to render it *extremely unlikely.* This goal is achieved with the help of a high redundancy of crucial components and extensive safety systems.

The second approach, followed in the German development of the HTR, and adopted by the South African PBMR, is to design the reactor in such a way, that a major accident involving a dangerous release of radioactivity is *excluded* under all imaginable conditions, by the *physical characteristics* of the reactor itself—without depending on additional safety systems. (This is also the approach, it should be noted, adopted by other advanced reactor designs.)

Obviously, common sense would naturally prefer the *second* approach. However, for various reasons, connected in part with the specific history of the development of nuclear energy, the *first* approach has predominated. This is connected with the fact, that *inherent safety* is very difficult, or even impossible, to achieve at an economically acceptable cost, for the light water reactor designs which have dominated commercial nuclear energy generation until now.

The basic physical characteristics of the standard, large-size LWRs now in use are such, that two basic sorts of serious accidents are possible, in principle:

- A *reactivity* accident—an uncontrolled, "runaway" chain reaction, resulting, for example, from a failure of control systems, improper operation, sabotage, and so on.
- An overheating, or even *"meltdown,"* of the reactor core, with rupture of fuel elements and large-scale release of radioactive substances from the core, which could conceivably result from failure of cooling systems, or their inadvertent or deliberate switching-off.

In fact, a serious accident of the first sort did occur once, namely, in Chernobyl, leading also to an explosion and fire with massive release of radioactivity to a large area. A relatively serious accident of the second type occurred in Three Mile Island. In the latter case, the dangerous levels of radioactive were successfully confined within the reactor building, and there was absolutely no significant health danger to the population outside the plant. The plant itself, however, had to be permanently shut down and dismantled at great expense.

The first type of problem is complicated by the fact, that the LWRs are refueled only from *time to time,* rather than continuously; thus, a new "charge" of fuel rods must have a sufficiently large excess of reactivity, to maintain the criticality of the reactor for many months, in spite of a substantial amount of "burnup" until the next scheduled refueling. In the event that all the control rods were, for some reason, suddenly withdrawn from the reactor, the chain reaction would rapidly grow out of control, with possibly disastrous consequences. In practice, the likelihood of a "runaway" reaction is rendered extremely remote, by a combination of automatic control, emergency shutdown, and other safety systems.

The second problem is exacerbated by the fact, that during its normal operation, a fission reactor accumulates a large inventory of heat-generating radioactive fission products. As a result, even after a successful "shutdown" of a reactor (that is, ending the chain reaction), the radioactive substances in the core continue to produce large amounts of heat. In the case of modern LWRs, this amount of heat is so large, that reactor components would be severely damaged, and eventually would melt, unless the heat-buildup were speedily removed by active cooling systems. To prevent such an eventuality, modern LWRs are built with several back-up cooling systems, so that the likelihood of a simultaneous failure of *all of them* is extremely remote.

"The total cost of generated electricity can be brought down to below *1.6 cents per kilowatt-hour*—a very competitive level, indeed!"

The state-of-the-art LWR reactors are, without doubt, extremely safe. However, that safety is ensured only by investment in complex safety and control systems, as well as special quality standards of manufacture of components ("nuclear grade"), which together account for a significant percentage (on the order of 30 to 50 percent) of the cost of a nuclear power plant. Furthermore, the modern plants are extremely complex, requiring very high skill levels in construction and in operation, which alone has tended to restrict their use mainly to advanced industrial nations.

Designs for light water reactors do exist, in which the possibility of the two major types of accidents, indicated above, is virtually eliminated, without depending on complex active cooling and safety systems. This can be done by reducing the amount of excess reactivity, and placing reservoirs of coolant water *above* the reactor core, so that a sufficient flow of coolant is ensured by gravity alone. However, these designs are very far removed from the present commercial LWRs, and have been rejected on the grounds of too high costs. The principal difficulty lies in the physical basics of the LWR technology, which was originally developed for military use (U.S. nuclear submarines), under circumstances where safety considerations were much less stringent than for commercial nuclear power today.

The HTR in general, and particularly the pebble-bed design, was conceived from very early on with a view toward inherent safety, based on physical principles, without the need for any special safety systems or exotic design features. Rather than contributing to increased costs, the inherent safety features greatly improve the economic viability of the reactor.

Two Features of Inherent Safety

Two basic features are key to the "inherent safety" realized by modular pebble-bed reactors like the PBMR:

First, HTRs are generally characterized by a *strongly negative temperature coefficient.* This means that the efficiency of the chain reaction—the average number of fission reactions triggered by a given neutron in the reactor—*decreases* very rapidly with temperature. This is achieved by the choice of core geometry and the moderator material (mainly graphite). As a result, a significant increase of temperature above the designed operating temperature (ca. 900°) immediately causes the reactor to become subcritical; in other words, the chain reaction stops by itself, without any outside intervention.

This "automatic shutdown," which

occurs within fractions of a second by a natural physical process, was demonstrated repeatedly on the AVR test reactor in Jülich. For example, at maximum power, the control rods were suddenly withdrawn and the cooling systems turned off—a suicidal act in a normal reactor! With the AVR, nothing happened; the chain reaction immediately ceased, and the reactor temperature remained within the tolerance of the fuel elements.

Second, the dimensions of the PBMR reactor and its relatively low power density are chosen so that the natural diffusion of heat through the reactor vessel provides sufficient "passive cooling" to keep the maximum core temperature, after a reactor shutdown, well within the 1,600° tolerances of the fuel elements.

As a result of these two main properties, a reactivity accident and the release of significant amounts of radioactivity are both excluded under *all* conditions, including deliberate sabotage of the reactor. *No special safety systems are required!* This means an enormous cost reduction as well as major simplifications in the design, construction, and operation of the reactor.

Waste Handling

The PBMR system has been designed to make the handling of nuclear waste particularly efficient and safe. Provision is made in the design of the PBMR for the storage of spent fuel. There is enough room for it to be stored in dry storage tanks for the 40-year lifetime of the plant, during which time no spent fuel need be removed from the site. After the plant has been shut down, the spent fuel can be stored on site for another 40 years before being sent to a final repository (as with other spent nuclear fuel).

The properties of the PBMR's spherical fuel elements make spent fuel elements much easier to store than fuel rods from a PWR. Thanks to the encapsulation of the fuel particles by silicon carbide coatings, the radioactive fission products are fully retained inside the fuel elements. The extraordinary stability and corrosion resistance of the silicon carbide material, ensures the long-term isolation of the radioactive products for approximately a million years, which is longer than the activity even of plutonium. Thus, a final storage of spent fuel elements in intact form, exploiting their built-in encapsulation properties, becomes a feasible and cost-effective option.

The Demonstration PBMR

Expected shortly is the final "green light" from the South African government, to go ahead with the first, demonstration PBMR. Preliminary construction activities could commence in the first half of 2001. Completion of construction and first criticality of the reactor should occur about three years later, to be followed by one year of commissioning activities. The plant, therefore, could go into commercial operation in 2005.

The decision on the location of the demonstration PBMR is also expected to be made this year, and Eskom has acquired various sites along the South African coast for future siting of nuclear power stations. The demonstration PBMR will probably be built at an existing, registered nuclear site such as Koeberg, where Eskom has sufficient ground and more than adequate infrastructure to accommodate the plant.

Jonathan Tennenbaum is the editor-in-chief of the German-language Fusion *magazine, and works closely with the Schiller Institute and economist Lyndon LaRouche on development programs.*

Notes

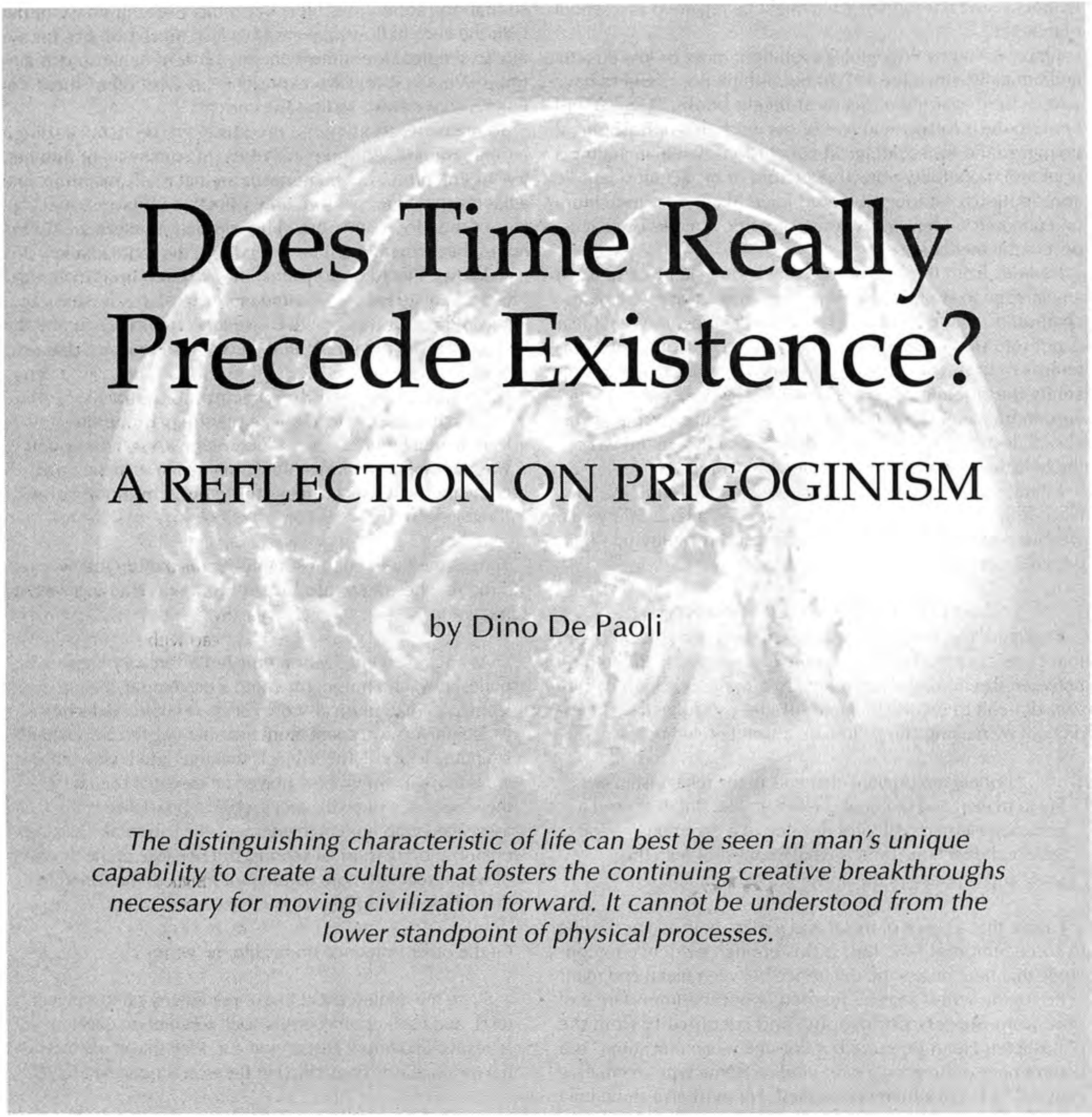
1. See "South Africa Plans Advanced High-temperature Nuclear Reactor," an interview with Eskom Project Manager David Nicholls, *21st Century,* Spring 1997, p. 26.
2. A 290-page report on the Eurasian Land-Bridge, *'The New Silk Road'—Locomotive for World-wide Economic Development*, was published in 1997 by *Executive Intelligence Review*, P.O. Box 17390, Washington, D.C. 20041-0390.

Does Time Really Precede Existence?

A REFLECTION ON PRIGOGINISM

by Dino De Paoli

The distinguishing characteristic of life can best be seen in man's unique capability to create a culture that fosters the continuing creative breakthroughs necessary for moving civilization forward. It cannot be understood from the lower standpoint of physical processes.



NASA

The Earth in motion, one of a series of time-lapse images taken by the Galileo spacecraft, about 1.3 million miles away.

Ilya Prigogine is a world-renowned scientist, who won the Nobel Prize, in 1977, for his theory of dissipative structures, and who, in 1989, was awarded hereditary nobility and the title of Viscount by the King of Belgium. He is part of a wide group of scientists who are seeking a new global paradigm for science. This includes trying to find solutions to problems in many domains of science simultaneously.

In Prigogine's case, this new paradigm also means a war against determinism, which he thinks has infected all of Western science through the concept of "reversible time." This notion of determinism contains a specifically Western dichotomy between nature and mind, according to Prigogine. His solution for that alleged problem, is to look for a new unity of the world, through a combination of thermodynamics (which traditionally handles irreversible time), and chaos-theory. Since the 1970s, Prigogine has produced an impressive list of popu-

I would like to dedicate this article to the memory of Dr. Robert Moon, a scientist and a man who lived in eternal time, and who admired Henri Bergson.

lar books, and has formed what might be regarded as a school of thought.[1]

I have followed Prigogine's evolution, more or less directly and critically, since the 1970s; but, I think it is useful to have a fresh look at some of his most recent books.[2] Here, I will limit analysis to two features of his work, his philosophical premises, and his sociological conclusions, while including a brief and, hopefully, objective picture of his actual scientific contributions. Although I would have liked to include more on economics, I have only some sporadic remarks on that aspect of the matter here.

I admit, from the beginning, that I look skeptically upon any attempt to study human nature from the standpoint of mechanics, no matter how much claim to express the nonlinear is put into that effort. Historically we have seen various attempts to base societies on some physical theory, most recently the so-called Social Darwinism, whose political perversion by the Nazis still lingers in our memory. Ecologism is also an ideology which tries to define societies on the basis of the holistic equation: Man = biology = nature.

I think that the contrary approach is more useful. We may learn from this, that there is a reason why, after 2,500 years, we can still learn about the human mind by studying Plato, who did not use any type of mechanics.

Part 1: Time and Determinism

Prigogine has tried to get at an old and difficult problem, that classical paradox of human experience: the dichotomy between freedom and necessity, two realities which can be very difficult to reconcile. He thinks he can solve the contradiction, by making "time" into an absolute reference:

> . . . [T]here are original elements in the relationship of life to matter, and of consciousness to life. But they need a common element: All must develop in a common temporal direction. Time is what establishes both the unity and diversity of the universe [Spire, p. 76].

I agree that a piece of metal and a man, both age according to some temporal law; but, is this enough evidence to conclude that time makes the difference between metal and man?

Prigogine writes that he learned about the importance of time from process-philosophy, and specifically from the philosopher Henri Bergson; but does he mean that "time" is a determinant of Bergson's *elan vital,* or some type of creative causality? He must be more explicit. He must also show how "time" itself can be susceptible to qualitative changes that reflect Bergson's assumption (which I think is valid), that there is something unique in human nature. But now let's look at time a bit more minutely.

Our life, our activity in the world, all indicate to us the passing of time. We get older, but never younger, we try to plan our own and other's future, but we have no means to change our past. The Germans express it nicely, "It is snow from yesterday!" It is gone ! But not all the past is gone; memories are affecting our present, even as we already imagine the future, although all seems to move only in one direction, so that one sometimes feels like simply letting oneself float with the current flow, like a rubber ball on a river. But is it really so simple? Does time mean the same to a man and an animal? What is it that we experience as "freedom" from this flow? Can we swim against the current? If yes, how?

To measure, to know, to meditate, we seem to require a moment of rest. All three activities, in some way or another, try "to stop time," but their means are not really the same. The ancients started to measure time using the visible "spatial" cycles of the Moon and Sun. Whoever tries to measure always hopes that something, if not everything, does not change. It is well known that to clean your shoes, it is best to stop running! The ancients tried to limit measure to "static" events. But, things did not improve with the inclusion of motions and the invention of "dynamics." On the contrary, Prigogine tells us:

> [I]ndeed, it was the incorporation of time into the conceptual scheme of Galilean physics that was the starting point of Western science. Surely this starting point was a triumph for human thinking, but it is also the origin of the problem which forms the theme of this book [Prigogine 1996, pp. 9-10].

Time is the theme of most of his books, but Prigogine's love of time reaches deep into his soul in a way that arouses my compassion:

> As an adolescent, I was fascinated by archaeology, philosophy, and music. My mother used to say that I learned to read musical scores before I could read letters. At the university, I spent more time playing the piano than attending lessons! The subjects that interested me were always those in which time played an essential role, be it the emergence of civilizations, ethical problems associated with human freedom, or the temporal organization of musical sounds. But because of the threat of war, it seemed more rational for me to start a career in the *hard* sciences [Prigogine 1996, p. 66].

Of the other influence on his life, he writes:

> Since my adolescence, I have read many philosophical texts, and I still remember the spell *L'Evolution Creatrice* [*Creative Evolution*] cast on me. . . . I felt that some essential message was embedded in Bergson [Prigogine 1977].

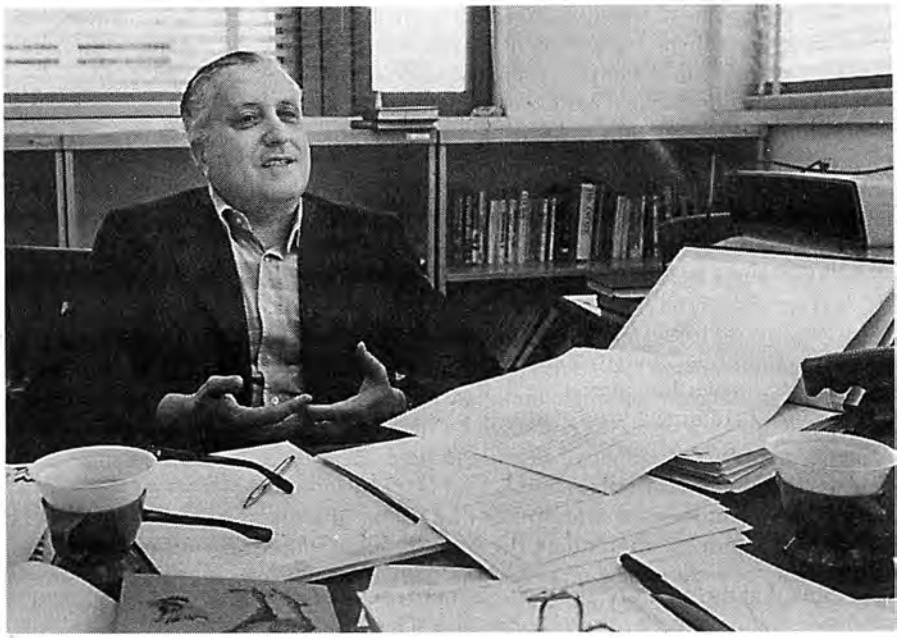
Prigogine says, that after Bergson, he also followed Whitehead, Popper, and Heidegger. It is probably from these latter figures that he transformed his view of the issue of time into the classical pair: Being-Becoming. One of the first of his "popular" books, in 1980, was *From Being to Becoming,* whose title alone already tells us Prigogine's side in the debate. In his more recent books he stresses, instead, that he seeks the reconciliation of the two terms, and, for once, he even quotes Plato in a positive light:

> [F]or Plato . . . we need Being and Becoming, because if truth is linked to Being, to a stable reality, we can conceive neither life nor thought, if we disregard Becoming [Prigogine 1996, p. 19].

1. See Prigogine's works listed in the bibliography.
2. See Prigogine 1996 and Prigogine and Stengers.

He argues, that with modern science things became worse:

> The duality of Being and Becoming has haunted Western thinking from its beginnings. . . . The formulation of the *laws of nature* brought a crucial element into the ancient debate. In fact, the laws enunciated by physics do not have as their aim to negate Becoming in favor of Being. On the contrary, they want to describe motions. . . . Nevertheless, their formulation constitutes a triumph of Being over Becoming [Prigogine 1996, p. 19].



Courtesy of the Ilya Prigogine Center for Studies in Statistical Mechanics and Complex Systems, University of Texas at Austin

Ilya Prigogine: *"The duality of Being and Becoming has haunted Western thinking from its beginnings. . . . The formulation of the laws of nature brought a crucial element into the ancient debate."*

Classical mechanics, whose origin is commonly mis-attributed to Galileo, adopted a form of "no-time," even while studying and using time, by assuming that time has no recognizable directionality. If a planet were to rotate in the opposite direction, the laws describing its motion would be the same, and so would be our measure of time based on its cycle. A pendulum marks the same time, whether it swings right-to-left or left-to-right; mechanical reversibility seems to make time impotent. This indifference to real changes, seems to render nature determined and predictable: Once one knows the present configuration of the planets, one can reconstruct their configuration for 40,000 B.C. or for 40,000 A.D.—pending no destruction or creation in the meantime!

But Newtonianism has made a global law out of this, so that not only the positions of the planets, but everything else in nature as well, seems to be determinable. This is the basis of that "determinism" which conceives of Nature as fully preordered. It presumes, consequently, either that we are pre-ordered too, or that what we do has no real physical significance or influence.

Thus, Prigogine makes scientific "determinism" his main enemy; but he cannot restrain himself from trying to get at something else:

> Many historians underline the essential role played by the Christian God . . . in such [deterministic] formulations of the laws of Nature. . . . The conception of a passive Nature, submitted to deterministic laws, is a distinguishing characteristic of the West [Prigogine 1996, p. 20].

Obviously, such an impotent Western culture, built around an uncreative God, could produce only static societies, and the typical exponent of such a culture, according to Prigogine's fruitful imagination, would be not Newton, but Leibniz!:

> If Leibniz has achieved the success that we all know, it is due to the fact that he combined two ideas: on one side he brought his reader nearer to the divine conscience—the future is already here; on the other side, he justified the idea of a well-ruled, hierarchical, and submissive society. . . . Science had been a Promethean enterprise. But, with determinism, it became a sad enterprise, where man found himself a bit *outside the universe* [Spire, p. 80].

Normally after encountering such a series of misstatements, I would stop reading a book, for they are the recognizable signature of "New Age" varieties of "holism," an anti-Western banality which blames Christianity for having pushed man to destroy Nature, and so on. One always has to wonder: By what miracle did Prigogine save himself from the virus of such a terrible Western culture? Yet, Prigogine assures us that he is not a "New Ager," that he is against post-modernism. And so we restrain our impulses. Did he not sign the Heidelberg resolution, circulated at the 1992 United Nations Earth Summit, which asserted the importance of science and technology in bettering the condition of mankind? Rather than pass over the subject of Prigogine's confused argument, let us try to see if the alternative of "Eastern" monism is really the solution to all our problems.

Are We 'a Bit Outside of the Universe?'

In reality, both Western and Eastern philosophies run into difficulty, not in proposing some kind of unity of man and nature, but in explaining the *differences* inside that unity; that is, man's specificity. In my opinion, the path out of "determinism" must lead past the paradox which seems to scare Prigogine. One must clarify what is meant by that feared "outside of the universe."

Prigogine himself, recognizes that:

We observe the emergence of a science which . . . confronts us with the complexity of the real world, a science which allows human creativity to unfold itself as a singular expression of a basic trait common to all levels of nature [Prigogine 1996, p. 16].

What does "singular" mean here? Can we specify it a bit more, and draw out the consequences?

Before we see if, and how, Prigogine answers these questions, I think it is useful to bring into the picture Henri Bergson's 1907 book, *L'Evolution Creatrice*. This is an admitted key reference for Prigogine; so, it cannot be suspected of suffering from the terrible "Western-Leibnizian-Christian" virus. Nevertheless, Bergson, although limited by his unsatisfying intuitionism, touches upon precisely what Prigogine seems to want to run away from. Specifically, in this book, Bergson reacts against the reductionism and Social Darwinism of his time, and introduces the standpoint of a living universe, which brings him to differentiate between *duration* (*durée,* that is, lived or experienced time) and the spatialized *time* of science, measured by clocks.

To get at Bergson's idea of duration, one has to start from his concept of existence:

[F]or a conscious being, to exist means to change; to change means to mature oneself; to mature oneself means to re-create oneself, without end [Bergson, p. 7].

This process of existence is the duration, the *elan vital* (life force, or consciousness), which is visualized as evolutionary nature. But the process of evolution is not a simple continuous line. As Bergson stresses, against Darwin:

From this standpoint, it is not only consciousness which appears as the motive power of evolution, but even more, among the conscious beings themselves, man comes to occupy a privileged place. Between man and the animals, the difference is not merely one of degree, but of their very nature [Bergson, p. 183].

In man, consciousness, splits into two forms: an intuition which is related to the life-instinct, and an intelligence. Bergson thinks that intelligence, the visible expression of the activities of *Homo Faber,* creates measure, geometry, tools, science, and so on; but that the real power lies somewhere else:

Intelligence . . . seeks, first of all, to fabricate. But does it fabricate just to fabricate, or could it be pursuing, involuntarily and unconsciously, a different aim? To fabricate means to give form to matter, to soften and to bend it, to convert it into an instrument, so as to master it. It is this mastering which profits humanity, much more than the immediate material invention itself. If we derive an immediate advantage from the fabricated object, as an intelligent animal could do, even if this advantage is all that the inventor has sought, this is but a small thing in comparison to the new ideas, the new thoughts, that the invention can give rise to, as if it had achieved, as its essential effect, *our elevation above ourselves,* and, with that, the expansion of our horizons. . . . So that, in the final analysis, Man would be the ultimate reason for the entire organization of life on our planet [Bergson, pp. 184, 186].

Man masters, and humanizes nature, through creative acts which bring us *above* the present horizon, sustained by a technological evolution which is never conceived as an aim in itself.

Bergson here seems to be much closer to the Oratorians (a French Catholic teaching order founded in th 17th century and influenced by Leibniz) and Lazare Carnot (another among Prigogine's adopted enemies), than to some of Bergson's own, modern romantic followers! How to communicate and describe this process of elevation of oneself and nature in general? How to communicate creative ideas? Bergson recognizes the limit of descriptive intelligence:

If science is to help us to expand our capability for action over things, and if we cannot act without inorganic matter as instrument, science can and will continue to treat the living as it treated the inorganic. But it will then become clear, that the more science reaches to the depth of life, the more the knowledge it provides us with becomes *symbolic* [Bergson, p. 200].

We can, nevertheless, arrive at the goal:

In the Absolute, we exist, move, and live. . . . Through the combined and progressive development of science and philosophy, we reach to the depth of Being itself. . . . By renouncing the artificial unity which understanding imposes from the outside . . . we will perhaps find the true inner and living unity. For the effort we exert in overcoming the pure understanding, brings us into some much wider realm [Bergson, p. 200].

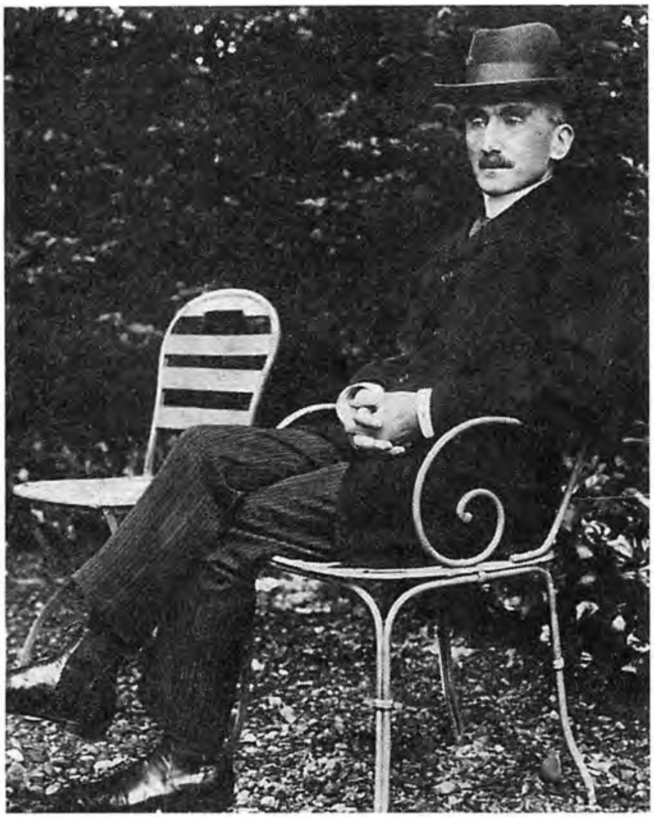
There, where the real lasting moments are:

We then re-enter into the pure duration, where the past, always in motion, becomes continuously larger out of a present which is absolutely new. . . . By our sense of the duration, I mean the coincidence of our Self with itself. . . [Bergson, p. 201].

This moment is not just a dead instant:

The more we become conscious of our progress into the pure duration, the more we feel the different parts of our being entering one into the other, and our entire personality concentrating itself into a point, or better into a tip, that inserts itself into the yet-to-come, prodding it ceaselessly. In this consists life and free action [Bergson, p. 202].

We can now leave the subject of Bergson's differences with Prigogine. But let us keep in our memory that there is "time" and "time": the dead instant of a bad photo, and the infinite moment caught by a classical painting, moments whose traces are left even on the face of a just-deceased person. The consciousness of such "moments," which at once expand the



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Henri Bergson *(1905 photograph): "The more we become conscious of our progress into the pure duration, the more we feel . . . our entire personality concentrating itself into . . . a tip, that inserts itself into the yet-to-come, prodding it ceaselessly."*

horizon and place us outside of, and undetermined by, any given, is what fills human existence and makes it endure.

From the Upanishads, to Plato, to St. Paul, to St. Augustine, to Cusa, to Pascal (to mention only few "Western" thinkers), all tell us the key to the paradox of the "outside," which Pascal sums up so poetically in the *Pensée:*

> It is not in space that I must seek my dignity, but from the ordering of my thinking. . . . As space, the universe grasps me and swallows me up like a point; as Reason, I grasp the universe [*Pensée,* n. 348].

Note how, in the process of measuring, we often experience the tendency to exclude real time, in favor of the spatial cycles. Whereas in the process of knowing, in confronting truth, one seems also to want to escape time—but now in a different direction. As Pascal hints, when we really think, we rise above the objects of experience. Thinking is real, its effect is lasting, if and only if it *changes* the simple flow of present events, as if from outside that flow.

Thus, Prigogine comes nearer to what I want to express, when he writes :

> But, knowledge does not merely presuppose a link between the knower and the known; it demands that this link create a difference between past and future. The reality of the Becoming is a condition *sine qua non* for our dialogue with nature [Prigogine 1996, p. 177].

Precisely! But *we,* rather than "the link," create, or do not create the difference! One must inject a little personality into the categories and relations of a process! A process which, according to the results we have achieved up to now, could be so summarized: To exist one must know, and to know one must be able to create differences. In the next section we will try to find out how to add that, to be able to create changes one has to avoid introducing absolutes into nature.

A Changeable Nature

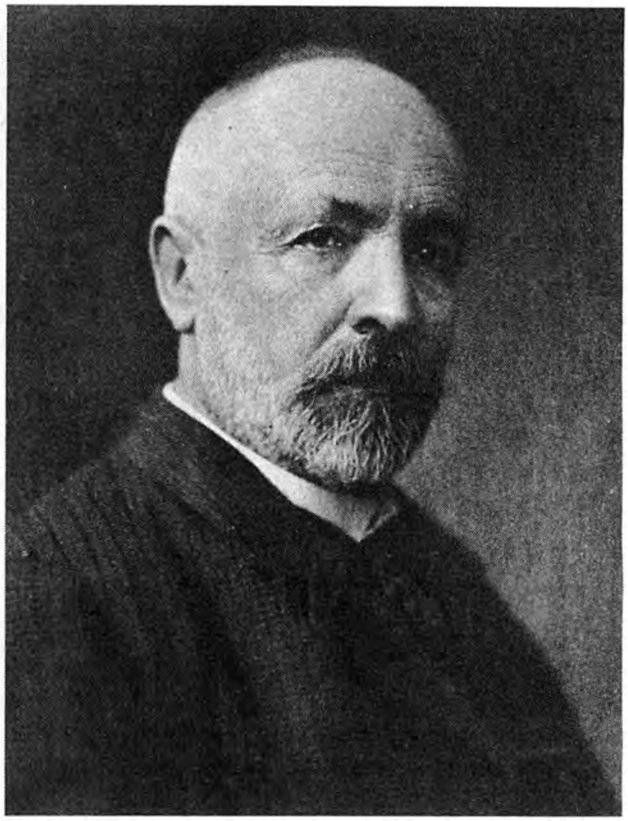
Bergson notes that in certain moments, "we live in the absolute," and this is the source of our free actions. Contrary to Prigogine's statements on the subject, Christianity, in order to safeguard man's moral freedom, warned us, through St. Paul, against the tendency to enslave ourselves either to some formal construction, or to an unchangeable divinity located in nature:

> Howbeit then, when ye knew not God, ye did service unto them which by nature are no gods.
>
> But now, after that ye have known God, or rather are known of God, how turn ye again to the weak and beggarly elements, whereunto ye desire again to be in bondage?
>
> Ye observe days, and months, and times, and years [*Galatians,* 4,8-10].

St. Paul's arguments are the same as those which led Plato, in the *Timaeus,* to conclude the existence of a created time

Blaise Pascal: *"It is not in space that I must seek my dignity, but from the ordering of my thinking. . . . As space, the universe grasps me and swallows me up like a point; as Reason, I grasp the universe."*

Gottfried Leibniz: *"I have demonstrated that space is nothing else but an order of the existence of things observed as existing together . . . besides that there is no real space outside of the material universe. . . ."*



Georg Cantor: *"I join Leibniz in calling the simple element of nature . . . out of which matter is composed, Monads or Unities."*

and space. These are also the same reasons for Leibniz's rejection of Newton's absolute space and absolute time, as expressed in the following:

> I have demonstrated that space is nothing else but an order of the existence of things observed as existing together . . . besides that there is no real space outside of the material universe. . . .[3]

and,

> Time is the order of existence of not-simultaneous things. . . . [T]hus time is the universal order of changes.[4]

This is not a subjectivist approach, for which Prigogine seems to reproach Leibniz in some of his books. It is a subjective science, whose meaning is best understood from the standpoint of Bergson's locating man in the absolute: We are the subjective form of a real process.

It is Prigogine who appears subjectivist, locating an absolute time outside of us, when he writes,

> *Time precedes existence* [Prigogine 1996, p. 189].

And,

> In this perspective time is eternal. We have an age, our universe has an age, but time has no beginning and no end [Prigogine 1996, p. 193].

One could simply reply: *If time precedes existence, then time does not exist!*

A logical contradiction must always reveal something more than a contradiction as such. Here, that something more is the ambiguity of the term "time" in Prigogine. This ambiguity thus leads to the introduction of his Sophist's type of subjectivism. When human knowledge hits against some unchangeable physical reality, then truth disappears in favor of opinions, and creativity becomes a game without responsibilities.

There is a tradition in the West (which Prigogine has chosen to ignore), running from Plato through Kepler to Leibniz, which seeks to unite Man with his creative nature, without nullifying his moral freedom. This tradition rejects not only absolute space and time, but also the absolutely dead, fixed atoms. Leibniz's concept of an elementary quantum of action, the *monad,* is the most modern and elaborated form of this school. Following Leibniz, Ampère derived experimentally his asymmetric and charged atoms, which anticipated some of the present images of elementary atoms.[5] Georg Cantor, in 1885, summarized the Leibniz-Ampère connection in this way:

> The Hypothesis forming the basis for most theoretical investigations of natural phenomena has never satisfied

me very much. . . . [T]he theoreticians . . . either allow a complete indeterminacy to govern the ultimate elements of matter; or . . . they take them to be so-called atoms of indeed very small but still existent extension in space. I had no doubt that a satisfactory explanation of nature implies that the . . . elements of matter must be assumed as actual infinite and without extension. . . I was reinforced in my thinking by the work of . . . physicists like Ampère, Wilhelm Weber. . . . I join Leibniz in calling the simple element of nature . . . out of which matter is composed, Monads or Unities.[6]

Interestingly enough, it is Alfred North Whitehead, the second of the inspirers of Prigogine, who, more clearly than that pupil, recognizes the founder of the monadic tradition, and tries to make use of it epistemologically.

In 1925, Whitehead wrote *Science and the Modern World,* where he admits his debt to a Bergson without vitalism, because, he writes, vitalism recreates dualism by rejecting mechanism in Life, but not in matter. His main criticism, however, is directed at materialism, which mistakes an abstract system of mathematical physics for the concrete realities of nature, realities which are, in fact, to be seen as "organisms." These are unities, whose totality influences the quality of all its subsystems, so that an electron inside an organism can be considered different from the same electron external to it.

Whitehead goes still further, to say that evolutionism is not compatible with materialism, because the atoms conceived by materialism are not able to evolve; they are considered ultimate, absolute substance. In materialism, evolution could mean only a description of the changes in the external relations between parts of matter. Instead, Whitehead, among others, sees in Leibniz a reference for his own concept of organism.[7]

In 1929, in his main work, *Process and Reality,* Whitehead tries to solve the paradox of the monism of Baruch Spinoza and Giordano Bruno with his theory of organism, a solution which, in my mind, Leibniz already had found, but Whitehead still feels the need to correct. Here, however, I cannot enter in the details of the controversy, because as I said, I wish to use Whitehead only as an instrument, to bring to light a tradition which his student Prigogine seems to overlook. I will try to summarize the relevant point with few direct quotes from the book:

In all philosophic theory there is an ultimate which is actual by virtue of its accidents. . . . In the philosophy of organism, this ultimate is termed "creativity"; and God is its primordial, non-temporal accident [Whitehead 1978, p. 7].

This describes a form of becoming, but it needs some specification:

There is a prevalent misconception that "becoming" involves the notion of a unique seriality for its advance into novelty. This is the classical notion of "time," which philosophy took over from common sense. . . . [T]he term "creative advance" is not to be constructed in the sense of a uniquely serial advance. . . . The actual occasions are the creatures which become, and they constitute a continuously extensive world. . . . Thus the ultimate metaphysical truth is atomism [Whitehead 1978, p. 35].

Atomism derived from Leibniz, but with a distinction:

This quantum [atom, organism] is constituted by its totality of relationships and cannot move. Also the creature cannot have any external adventures, but only the internal adventures of becoming. Its birth is its end. This is a theory of monads; but it differs from Leibniz's in that his monads change. In the organic theory, they merely become [Whitehead 1978, p. 80].

We will pass over the differentiation from Leibniz, and instead investigate from whence this "quantum" tradition comes:

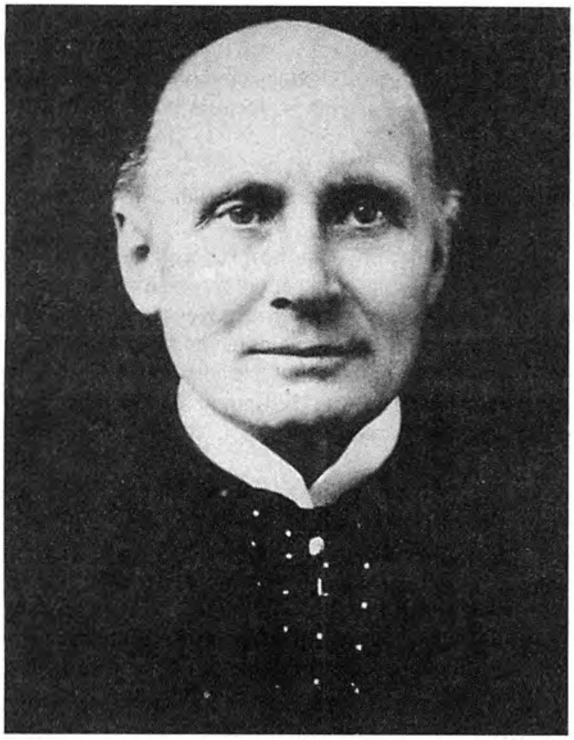
The safest general characterization of the European philosophical tradition, is that it consists of a series of footnotes to Plato. . . . Thus, in one sense, by stating my belief that the train of thought in these lectures is Platonic, I am doing no more than expressing the hope that it falls within the European tradition. But I do mean more: I mean that if we had to render Plato's general point of view . . . we should have to set about the construction of a philosophy of organism. In such a philosophy, the actualities constituting the process of the world, are conceived as exemplifying the ingression or "participation" of other things which constitute the potentialities of definiteness for any actual existence. The things which are temporal arise by their participation in the things which are eternal. The two sets are mediated by a thing which combines the actuality of that which is temporal with the timelessness of what is potential. This final entity is the divine element in the world. . . . Apart from such orderings, there would be a complete disjunction of eternal objects unrealized in the temporal world. Novelty would be meaningless and inconceivable. . . [Whitehead 1978, pp. 39-40].

and,

. . . [E]ternal objects, as in God's primordial nature, constitute the Platonic world of ideas [Whitehead 1978, p. 46].

And, later, we arrive at the crucial consequence:

3. Gottfried Leibniz, in his fifth letter to Samuel Clarke, in Loemker (ed.), p. 700, paragraph 29.
4. Gottfried Leibniz, "The Metaphysical Foundations of Mathematics," in Loemker (ed.), p. 666.
5. See L.P. Williams in *Contemporary Physics*, Vol. 4 (1962), p. 121; and C. Blondel, *Ampère et la Creation de l'Electrodynamique* (Paris: Editions Biblioteque Nationale, 1982), p. 122.
6. Georg Cantor, *Gesammelte Abhandlungen* (Collected Treatises), Ed. Ernst Zermelo (Berlin, 1932), p. 275
7. See Whitehead 1979 in the bibliography. On the issue of materialism and evolution, see also De Paoli 1997b in the bibliography.



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Alfred North Whitehead: *"[E]ternal objects, as in God's primordial nature, constitute the Platonic world of ideas."*

> Newton could have accepted a molecular theory as easily as Plato, but there is this difference between them: Newton would have been surprised at the modern quantum theory. . . . Plato would have expected it [Whitehead 1978, p. 94].

It is precisely Plato's solution to the relation between the "two sets," in the form of "participation," which makes his method and ideas so modern. Whitehead in his own "reconciliation," echoes Plato a bit:

> The corresponding element in God's nature is not temporal actuality, but is the transmutation of that temporal actuality into a living ever-present fact [Whitehead 1978, p. 350].

It is interesting to note here, that Georg Cantor had already given a bit of help on this issue of the "one-many," while Whitehead's sometime associate, Bertrand Russell, had fully failed, and decided, instead, that it was better to drop "the one" so as to save the "the many."[8]

Leibniz's "theological" version of the solution, should now become clearer:

> For a sufficient reason for existence cannot be found merely in any one individual thing, or even in the whole aggregate and series of things. . . . The reason for the world therefore lies in something extramundane, different from the chains of states, or series of things whose aggregate constitute the world.[9]

It is this "extramundane," which seems to scare Prigogine away from Leibniz, not realizing that Bergson and Whitehead, and Plato and Leibniz are after the same issue: The necessary existence of an "aboveness," which can guarantee the necessary reason for the existence of human moral freedom.

The. world can be made intelligible without falling into determinism, if we are able to get at a causality outside the simple mechanical time-series. Outside, means that one can operate on the total characteristic of the series. We are "singular" precisely because our potential to participate in this "eternal" reason, in what, for example, Lyndon LaRouche called the "simultaneity of eternity."[10] This and only this conscious and willful act, characterizes an adult creative discovery as an ordered transformation of the world of becoming.

Only from that standpoint, and we will come back to this at the end, it is possible to define a "value" and a directionality for man's transformation of nature. Simple creative impulses, are necessary but not sufficient to define human societies in relation to the rest of nature. We have to include the fact that human existence, reflecting the divine in nature, is sacred because it has a reason. Thus the necessity of its conservation, the humanization of nature, is a form of natural law.

We have analyzed man and time. Now, after some considerations respecting technology, we will follow Prigogine's own theory of physics. Then we will try to see, if he will be able to find his way back from physics to the minimum conditions for existence, as this requirement is posed by his own references: Bergson and Whitehead.

PART 2 : DISSYMMETRIES IN NATURE

Mechanics[11]

The model of the world which comes out of Newton's philosophy of nature, could be easily exemplified by a perpetual pendulum in an ideal fluid. We know that its axioms are based on materialism, which Whitehead correctly had called an abstract logical construction, and, as such, always clashes with reality. It was proved during Newton's life, that even a bird could not fly in a Newtonian ideal fluid, but birds do seem to fly! And Leonardo da Vinci, had shown already in 1580 that vortices were crucial to establish the lift necessary for flying.[12]

Leibniz not only rejected Newton's philosophy, but showed the necessity of introducing notions such as "work," or "fatigue," and vorticity, into any theory of nature. Such events, generally named *friction* or *attrition,* can play a locally constructive role, as in Leonardo's lift theory. Otherwise, their usual effect is to bring a mechanical system to a halt. Therefore, one can assume that there is no mechanical perpetual pendulum whose permanence could be assured indefinitely, unless one introduces the "demons" of J. Clerk Maxwell to push the pendulum when needed.

Leibniz, who, contrary to Newton, was neither a magician nor an alchemist,[13] introduced the role of a *vis viva* as base for the "duration" of the world in continuous transformation. *Vis viva* meant the same as "monad." Here lies the essential difference between Kepler's revolutionary definition of planetary orbits, which he associated with "Mind" of the planet (in his book *The New Astronomy*), and the mechanistic schema of empiricists Galileo, Newton, et al. This is the same anti-empiricist notion of solar orbits proven by the later work of

Carl Gauss. We see the role such non-entropic processes were made to play in respect to atoms, life, and cognition. And although Leibniz is not a vitalist, his *vis viva* comes nearer to Bergson's *elan vital* than to the "energy conservation" into which Hermann Helmholtz mistranslated it during the 19th century.

Following Leibniz's ideas, Lazare Carnot, a great French engineer, but not the mechanist Prigogine libelously made him out to be,[14] developed the science of technology.

In short: Carnot calculated the effects of friction in limiting the life and efficiency of all type of machines; and he supplied a scientific basis for the already suspected impossibility of the perpetuity of a motion of the same type. A machine, not only cannot create surplus energy, but also cannot even maintain itself in a stable equilibrium. With time and activity, any mechanical system tends increasingly, and "nonlinearly," to lose power, so that its socially useful output is constantly reduced, and the costs incurred even to maintain the same output, would increase exponentially. Hence the necessity of developing "better" technologies. Any human society which tries to maintain the same technological horizon, not only will really destroy nature, but will ultimately collapse by reducing its power for survival.

However, if machines cannot create energy-surplus, whence came the increased power which allowed *Homo Faber,* with up and downs, to augment his own survival potentials?

Carnot answers that we cannot apply to a human society, the ecological models appropriate to animal behavior. In the latter case, the determination of the energy flows is sufficient to define conditions for equilibrium and survival; but in the first instance, it is man's potential to positively *change* the energy flows which define the necessary and sufficient condition for survival! Carnot writes:

> The discovery of a new motive power in Nature is always a precious development . . . especially when it is used to help the action of man. . . . The ancients knew only few of such motive powers: . . .water, wind, animal power, etc. . . . [T]he mechanical theory can help in the evaluation of their effects. . . . But machines can only transmit energy they cannot increase it. The key lies in the motive powers. We have discovered new motive powers, or better we have created them, because although the elements are already pre-existing in nature, their low density make them not useful to man. Only artificially do they acquire the quality of motive powers, as in the cases of steam engines, black powder. . . .[15]

Thermodynamics

With the steam engine, a new complication appeared: All physical changes produce some amount of heat. But heat is a specific form of "friction." It tends naturally to radiate, to diffuse or dissipate itself homogeneously, without the possibility of being reconverted into work. The study of such heat engines, in which heat is converted to mechanical energy, is called "thermodynamics," and Lazare Carnot's son, Sadi, made the first contribution to this branch of science.

Subsequently, the focus of attention became more and more the dissipation, forgetting Carnot's lesson that a machine only exists *in conjunction* with creative cognition. This misemphasis led to the two so-called laws of thermodynamics by Rudolf Clausius, which set general limits for the conversion of one form of energy (for example, heat or chemical energy, to another (for example, mechanical work). This led also to Clausius's celebrated, universal, and pessimistic formulation. It is worth seeing how Clausius arrived at this "universalization."

In 1850, Clausius had written a first version of his laws, without any universalism. Then, in 1852, Clausius's associate

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Lazare Carnot: *"The discovery of a new motive power in Nature is always a precious development . . . especially when it is used to help the action of man. . . ."*

8. See De Paoli 1997a.
9. Leibniz, "On the Radical Origination of Things" in Loemker (ed.), pp. 486-87.
10. See LaRouche 1996, 1997, 1999 in the bibliography.
11. See De Paoli 1999 in the bibliography.
12. See De Paoli 1986 in the bibliography.
13. That Newton was a magician is known. What is new is that Prigogine's close associate I. Stengers seems now to defend Newton now precisely because of that fact. See I. Stengers and J. Schlanger, *Les Concepts Scientifiques, Invention et Pouvoir* (Paris: La Decouverte, 1989), pp. 124–132
14. See, for example, I. Prigogine and I. Stengers, *La Nouvelle Alliance* (Paris: Gallimard, 1979), or the English-language version, *Order Out of Chaos* (New York: Bantam, 1984).
15. For more on Carnot, see the author's articles "Carnot's Theory of Technology: The Basis for the Science of Physical Economy," *Executive Intelligence Review*, June 8, 1999, p. 65; and "Lazare Carnot's Grand Strategy for Political Victory," *Executive Intelligence Review*, Sept. 20, 1996, p. 14.

A Note on Nonlinearity

by Lyndon H. LaRouche, Jr.

In its strict use, the term nonlinear should be understood to signify, a physical-space-time geometry from which we exclude any mathematics which connects the dots with straight lines. The simplest example of this distinction is provided by efforts to map spherical surfaces on to plane surfaces. Thus, the transcendental nature of *pi,* as first defined by Cardinal Nicholas of Cusa in such locations as his *De Docta Ignorantia,* typifies the minimal definition for the epistemologically strict use of the term nonlinear. Cusa follower Johannes Kepler, was the first to apply this notion to astrophysics. The notion of a multiply-connected manifold, or hypergeometry, as defined by Carl Gauss and his follower Bernhard Riemann, sets the standard for a literate use of the term nonlinear today.

The popular misuse of nonlinear, as by John von Neumann and Prigogine after him, defines the term from the axiomatically deductive, formal-mathematical standpoint of a mathematics which assumes that the efficient connection among the dots of sense-perception can, and must be defined from the axiomatically linear standpoint of Paolo Sarpi's lackey Galileo Galilei, and therefore from the standpoint common to Newton, Descartes, Euler, Lagrange, Laplace, Cauchy, Cauchy, Hermite, Bertrand Russell, John v. Neumann, et al.

Typical of the difference is the fact, that although Newton's definition of gravitation is, mathematically, a simple derivation of Kepler's earlier first discovery of a measurable form of universal gravitation, as in Kepler s *The New Astronomy,* Newton's doctrine is shown to be axiomatically fallacious,l by virtue of the so-called three-body paradox, whereas, as Gauss later demonstrated, Kepler's original discovery of universal gravitation incurs no such paradox. Notably, Newton's approach was derived from the empiricist, axiomatically linear method of Galileo.

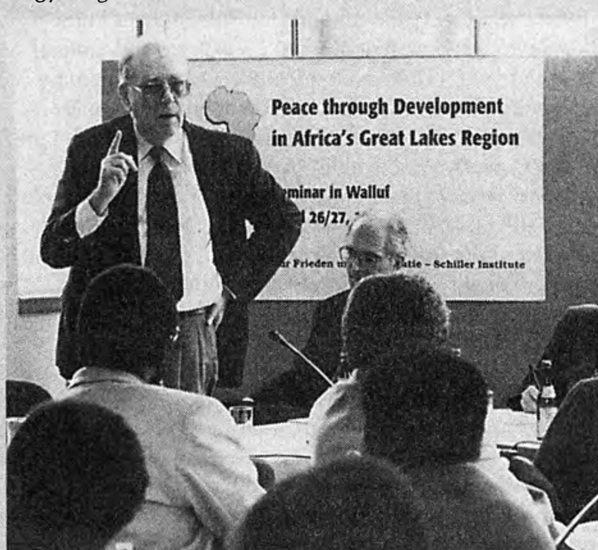
"The only epistemologically literate use of the term nonlinear, is situated within the domain of a generalized notion of Riemannian manifolds."

Formally, the only generally known, competent general definition of a nonlinear geometry, is that first stated by Bernhard Riemann in his 1854 habilitation dissertation, *On the Hypotheses Which Underlie Geometry.* Two features of that dissertation are of outstanding relevance for making that definition. First, that all *a priori,* axiomatic presumptions respecting space, time, and physical action must be purged from mathematical physics, and these replaced by experimentally proven universal physical principles, instead. This defines the meaning of the term physical space-time, and also defines the significance of the term multiply-connected manifold, or hypergeometry. Second, that deductive mathematical method and the assumption that two points are connected by straight lines, must be expelled from mathematical physics, and also mathematics itself, and straight lines replaced by those non-constant curvatures which correspond to an experimentally determined pathway of Leibnizian least action within the relevant manifold of *n* experimentally determined universal physical principles. Thus, the determination of the pathway of least action, is a matter of specially defined experimental proof of universal principle, not a question to be relegated to the mathematician's blackboard or digital computer.

From my discoveries and related work in the science of physical economy, it can be generally said that the only epistemologically literate use of the term nonlinear, is situated within the domain of a generalized notion of Riemannian manifolds.

The fallacy inhering in the vulgar use of nonlinear, as by a von Neumann or Prigogine, is that it perceives what may, or may not be a nonlinear pattern among observed, or merely conjectured, dots, from the standpoint of a formal mathematics which assumes that space-time is intrinsically linear-deductive in the very small. In reality, as in Kepler-Gauss astrophysics, it is precisely in that very, very small that the crucial elements of lawful expressions of nonlinear curvature of the relevant manifolds are lodged.

Economist Lyndon H. LaRouche, Jr. is a member of the Scientific Advisory Board of 21st Century Science & Technology *magazine.*



Chris Lewis/NSIPS

LaRouche speaking at a seminar on African development, sponsored by the Schiller Institute in April 1998.

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Rudolf Clausius: *"There is at present in the material world a universal tendency to the dissipation of mechanical energy."*

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Hermann Helmholtz: *"The entropy of the universe tends towards a maximum."*

Lord Kelvin, without any added experiment, wrote the following in the Edinburgh *Philosophical Magazine:*

> There is at present in the material world a universal tendency to the dissipation of mechanical energy. . . . [A]ny restoration is impossible. . . . [W]ithin a finite period of time to come the Earth must . . . be unfit for the habitation of man.

Four years later, in 1854, Hermann Helmholtz, a German mechanist friend of Kelvin, published a similar thesis. In 1865, after meeting Helmholtz, Clausius, in the second edition of his book, rewrote his now-famous two laws:

> (1) the energy of the *universe* is constant;
> (2) the entropy of the *universe* tends towards a maximum.

Thus, the "second law" of thermodynamics, now means that irreversibility, or entropy, is an index for the death of our universe, and not simply for that of an isolated machine. In other words, in this thermodynamics, irreversible time indicates the road to the cemetery.

Prigogine describes that situation in the following way:

> The distinction between reversible and irreversible processes is introduced in thermodynamics through the concept of entropy, which Clausius associated, in 1865, with the second principle of thermodynamics . . . Contrary to energy which is conserved, entropy allows us to establish a distinction between the reversible processes, in which entropy remains constant, and the irreversible processes, which produce entropy. The growth of entropy designates the direction of the future, both at the level of a local system and of the universe as a whole. This is the reason why A. Eddington associates it with the Arrow of Time [Prigogine 1996, pp. 26-27].

Death and Life

If the universe is nothing but a big rush to die, how could Life exist? The great biologist Louis Pasteur answered radically:

> You put matter before life, and you make matter eternal. How do you know that the progress of science will not force you to affirm that *life is eternal,* and not matter. You go from *matter to life,* because your present knowledge tells you that you cannot understand things in a different way. Who can assure me that in 10,000 years, we will not say that it is impossible *not*to go from *life to matter?*[16]

Pasteur indicates a necessary condition:

> The universe is a dissymmetric totality. I tend to think that life, in the form we observe it, must be a function of the dissymmetry of the universe.[17]

Erwin Schroedinger, one of the founders of quantum mechanics, intervened in this debate in 1945, with his book *What Is Life?* He assumed that Life is possible because living

16. Louis Pasteur, *Pages Choisies* (Paris: Editions Sociales, 1970), p. 56
17. *Ibid*, p. 62

organisms consume energy, perform work, excrete waste, and give off heat, while conserving life itself. Life thus represents what is called a stationary, steady-state, or open system. The Sun feeds life with its photons (visible light), which are absorbed by plants, give off their energy, and are re-radiated at lower energy (infrared). In Schroedinger's model, Life lives by eating non-entropy, or order, from the rest of the universe, like a parasite. Through such egoistic consumption, it conserves itself, but it also increases the total entropy of the universe and so accelerates its own death. By this order of logic, to be nasty, one could add to Schroedinger that active brains consume a lot of energy, so the more one thinks, the quicker the world will die! Prigogine mentions his own debt to Schroedinger:

> I have also been influenced by the beautiful book of Erwin Schroedinger, *What Is life?* Schroedinger discusses there, the metabolism of the living organism in terms of production and flux of entropy. . . . Life, concluded Schroedinger, feeds itself upon a "flux of negative entropy," but one can also say, and that was most important for me, that life is associated with entropy production, and so with the irreversible processes [Prigogine 1996, p. 72].

The research on how the irreversible flux of radiation which a Sun produces can eventually form complex molecular organic structures is crucial; but, there remains an unsolved question. Although we have now observed organic structures in the galaxy, we have no knowledge of how they are formed. L. Onsanger, who won a Nobel Prize in chemistry in 1968, studied irreversible processes, but limited himself to near-equilibrium conditions. Prigogine explains why he expanded on Onsanger's researches:

> From the very start, I always attributed to these [irreversible] processes a constructive role, in opposition to the standard approach, which only saw in these phenomena degradation and loss of useful work. Was it the influence of Bergson's *L'Evolution Creatrice,* or the presence in Brussels of a working school of theoretical biology? The fact is that it appeared to me that living things provided us with striking examples of systems which were highly organized, and in which irreversible phenomena played an essential role. Such intellectual connections . . . contributed to the elaboration, in 1945, of the theorem of minimum entropy production, applicable to non-equilibrium stationary states. This theorem gives a clear explanation of the analogy which related the stability of equilibrium thermodynamical states and the stability of biological systems, such as that expressed in the concept of "homeostasy" proposed by Claude Bernard [Prigogine Autobiography 1977].

Also useful in this connection, is the description of Prigogine's work given by the Nobel Prize committee in 1977:

> Prigogine has demonstrated that a new form of ordered structures can exist under such conditions [far from equilibrium], and he has given them the name "dissipative structures" to stress that they only exist in conjunction with their environment. The most well-known dissipative structure is perhaps the so-called Bernard instability [observed in 1900]. This is formed when a layer of liquid is heated from below. At a given temperature, heat conduction starts to occur predominantly through convection, and it can be observed that regularly spaced, hexagonal convection cells are formed in the layer of liquid. This structure is wholly dependent on the supply of heat, and disappears when this ceases. Quite generally it is possible in principle to distinguish between two types of structures: equilibrium structures, which can exist as isolated systems (for example crystals), and dissipative structures, which can only exist in symbiosis with their surroundings. Dissipative structures display two types of behavior: Close to equilibrium, their order tends to be destroyed; but, far from equilibrium, order can be maintained and new structures be formed [Prigogine Autobiography 1977].

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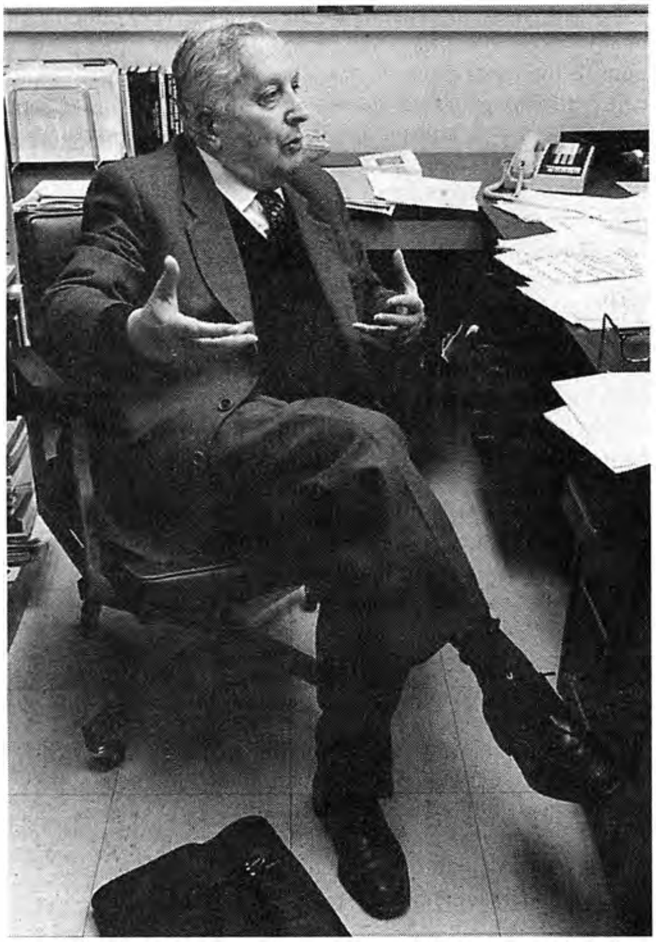
Louis Pasteur: *"The universe is a dissymmetric totality. I tend to think that life, in the form we observe it, must be a function of the dissymmetry of the universe."*

Here are some particularities of the dissipative structures, in Prigogine's own words:

> [S]ystems far from equilibrium do not lead anymore to an *extremum* of a function such as free energy, or the production of entropy. Consequently, it is no longer



Courtesy of the Ilya Prigogine Center for Studies in Statistical Mechanics and Complex Systems, University of Texas at Austin

Prigogine: *"Without the coherence of the irreversible processes of non-equilibrium the appearance of life on Earth would be inconceivable."*

> certain that the fluctuations are cancelled. It is only possible to formulate the *sufficient* conditions for stability, which we have baptized "general criteria of evolution.". . . While at equilibrium and near equilibrium, the laws of nature are *universal,* far from equilibrium they become specific; they depend on the type of the irreversible processes [Prigogine 1996, pp. 74-75].

Prigogine transformed the studied conditions into a new kinetical model, called the "Brusselator." But, he writes that:

> After the discovery of experimental oscillating chemical reactions, such as the Beloussev-Zhabotinsky reaction, the attention of scientists was attracted to coherent non-equilibrium structures [Prigogine Autobiography 1977].

The B-Z reactions, as they are called, observed in Russia in 1964, made visible a property here summarized:

> Chemical reactions are, in general, nonlinear. . . . [T]herefore, many possible solutions exist. . . . Among those solutions, only one corresponds to the thermodynamic equilibrium state and to the maximum entropy. This solution can be extended into the domain of non-equilibrium. . . . But the unexpected result is that the stationary states become, in general, unstable, starting at a critical distance from equilibrium. Beyond the first bifurcation point, a set of new events is produced: . . . oscillating chemical reactions, non-equilibrium spatial structures, chemical waves. We called these new forms of spatio-temporal organization "dissipative structures" [Prigogine 1996, pp. 75-76].

If the term "nonlinearity" is loosely defined, it is typified, in a non-equilibrium condition, by the fact that it seems to avoid pre-established "least action" paths, and instead goes through "bifurcation points," where it is not possible to foresee which of the two possible paths the reaction will "choose." Bifurcation points are similar to the familiar "critical points," where, for example, water assumes different physical states (ice, liquid, vapor), depending on conditions of temperature and pressure.

The discovery of such conditions for the existence of dissipative structures, brought Prigogine the Nobel Prize in 1977. But for him this was only the starting point to get at the question of the necessary condition for the existence of life, as he mentions here:

> Without the coherence of the irreversible processes of non-equilibrium, the appearance of life on Earth would be inconceivable [Prigogine 1996, p. 12].

But even the understanding of life is not the final aim. He writes:

> Can't the bifurcations help us to understand the process of innovation and diversification in other domains, apart from physics and chemistry? How to resist the temptation to apply these notions to problems regarding biology, sociology, or economy? [Prigogine 1996, p. 81]

Generalizations

Since the 1970s, not only did Prigogine not resist such temptations; on the contrary, although more and more by use of analogies, he has sought a general "Bergsonian" physics, able to bring man back into nature, inverting what he calls the marginalization of man accomplished by Copernicus, Darwin, and Freud:

> It seems to me that the physics far from equilibrium inverts this perspective. Human activity, creative and innovating, is not foreign to nature. One can consider it as an amplification and an intensification of traits already present in the physical world, and which the discovery of the processes far from equilibrium taught us to decipher [Prigogine 1996, p. 82].

But if man's activity is merely a quantitative *intensification or amplification* of material processes, then man will be fully determined by matter alone, despite any apparent nonlinearity!

As on the question of time, Prigogine here again falls into the Darwinian trap of a simple monism, based on materialism. Bergson and Whitehead must be very upset to see their pupil, at least in the above passage, fall so far away from his stated intentions, replaying the drama of the young Icarus, who for excess of "creativity," forgot to follow the advice of his father, the scientist Daedalus.

Yet, Prigogine seems to find a helpful moment of self-doubt, when he adds:

> But we are only at the beginning. There is still a very great distance between the most complex structures which we can produce in chemistry, even under the condition of non-equilibrium, and the complexity of the structures which we encounter in biology [Prigogine 1996, p. 82].

And, later, he adds another important distinction:

> Inside thermodynamics itself . . . additional conditions are necessary to observe the emergence of the dissipative structures. . . . And such forms of self-organization in physics are themselves necessary, but not sufficient, conditions for the emergence of the self-organization typical of life. The distinction between necessary and sufficient conditions, is essential to describe the narrative dimension of nature [Prigogine 1996, p. 150].

What Prigogine tell us here, has the soothing effect of a refreshing shower. If his thermodynamics cannot establish sufficient conditions for biology, then one would assume that this is even more the case for human societies, where, without the introduction of some form of *value* to the necessary condition for transition, one cannot differentiate between "folly" and creative acts—from his standpoint, both are nonlinear!

But Prigogine wants to get to the social models. And he does so by adding Chaos Theory to thermodynamics.

Enter Chaos

Prigogine's aim is to let "the arrow of time" be the unique, universal objective reality. For him, it alone is able to simultaneously define transitions and their directions. He thinks he has solved this for thermodynamics; but there is still all the rest of physics covered by classical, relativistic, and quantum mechanics. To include those areas within thermodynamics, he thinks he needs to use the so-called "chaos theory" of the radical empiricists and positivists, so as to reunify concepts like irreversibility and instability, entropy and unpredictability.

"Chaos theory" is a recently introduced, fancier name for the mechanistic, percussive-attractive-interaction systems of the Paolo Sarpi school of empiricists and positivists, such as Galileo, Galileo's student Thomas Hobbes, Bernard de Mandeville, Adam Smith, Jeremy Bentham, Thomas Malthus, Charles Darwin, and Thomas Huxley. Modern "chaos theory," which is traced more immediately from Bertrand Russell devotee John von Neumann, is a simple extension of the same axiomatic assumptions on which earlier forms of empiricism were premised. Otherwise, the systems studied by today's so-called "Chaos Theory," are a specific mathematical type of unstable systems, in which attention is focussed on cases where a small perturbation can create forms of apparently nonlinear amplification (the butterfly effect).

In such cases, forecasting becomes either very difficult, or nearly impossible. The difficulty in long-term weather predictions, is the usual example of such a system. We do not replicate here Prigogine's adventures in the realm of chaos. "Chaos theory" is very globalist in its appetites, gripped by a compulsion to mix a bit of everything; hence, its convolutions tend to throw normal readers into a spin of wild, more or less psychedelic impressions. These impressions are of the type: "we have solved all . . . almost all . . . well, in any case, some. . . ." Then, in one single page, appears the solution valid for sex and black holes, for mushrooms and galaxies!

Prigogine does not fully escape that tendency toward the psychedelically bizarre: although he limits his "solutions" to cosmology-chaos and quantum-chaos. I hope he has solved all that he says he has solved; in my most generous moments, I am able to adopt an attitude of "wait-and-see."

In cosmology, where he admits his use of a *Spielmodel,* (Prigogine and Stengers, p. 303), his main criticism is focussed against the standard theory, which leads to the identification of a "big bang," or "beginning" of our world, seen as a "singularity," that is a point at which our customary notion of space-time loses its meaning.

His alternative to that "big bang" is the following:

> As we are going to show, today we can conceive the big bang as an event associated with an instability, which implies that it is the point of departure of our universe, but not of time. While our universe has an age, the milieu whose instability has produced this universe would not have one age. In this conception, time has no beginning and probably no end! [Prigogine 1996, p. 14]

As to quantum mechanics, Prigogine recognizes that chaos has failed so badly here that, "many writer have drawn the conclusion that there is no quantum-chaos." (Prigogine and Stengers, p. 265). But, he also thinks he has a solution to this. I cannot judge, and therefore I limit myself to reporting the comment of a scientist, not generally unfriendly to Prigogine, and quoted in a book favorable to him:

> T]he problem . . . between Prigogine and quantum mechanics is a real one. In his *La Fin des certitudes,* he affirms that he is able to re-arrive at quantum mechanics. I must say that on this issue, I am very reticent. . . . I am waiting for the proofs. . . . And it seems to me, that the reason why it does not function, is that Prigogine has a problem to solve with quantum mechanics: He does not see any discontinuity between the physics he has done, and quantum mechanics [Spire, pp. 133-134].

I thus conclude treatment of Prigogine's physics, in which I have tried to be as objective as possible. I turn now to judge its application to the field which is actually the omega of his efforts: human societies.

Part 3: A Social Mathematics?

It is known that the Malthusian Club of Rome, during the 1970s, financed many studies in nonlinear systems-analysis, in order to push its ideologically motivated conceptions of population control. To achieve this, it used the work of famous scientists. The results of each study, always promoted by big headlines in the media, usually became short-term intellectual fads. I will give two examples:

• René Thom, a famous French mathematician of the 1970s, produced one such systems-analysis study that came to be called "catastrophe theory." Twenty years later, Thom had the honesty to admit:

> There is not a specific domain where, one could say that, catastrophe-theory facilitated the discovery of a technique, a tool, or a means to solve a concrete problem. . . . To return to the applications, people proposed a considerable number of them: the aggressivity of dogs, stock-market crashes, prison riots, the manic-depression, pulsations of the heart, etc. . . . In 1974, the media headlines were considerable . . . [but today] it is true that, in a sense, the ambitions of the theory have collapsed.

• David Ruelle, one of the fathers of chaos-theory in France, wrote in 1992:

> In 1975, a new paradigm appeared and it was baptized "chaos,". . . [A] few years later, chaos became a fashion and the theme for international conferences. Soon after, chaos was elevated to the dignity of nonlinear science. . . . The success of chaos took the form of a media event. . . . In the physics of chaos, unfortunately, increasing fame has gone hand in hand with a decline in the production of interesting results, no matter the triumphal announcements of Earth-shattering results.
>
> One must see that in many domains (ecology, economy, social sciences), even if one succeeds in writing some equations of time evolution, these equations would have to change slowly with time, because the system learns from nature and changes with it. For such systems, then, the impact of chaos is limited more to the level of scientific philosophy than to quantitative science.

Prigogine's Social Mathematics

Prigogine bases his own social mathematics on the assumption derived from chaos-theory, that "uncertainty," which for him characterizes social forecasting, is not the result of our lack of knowledge, but an essential property of nature:

> . . . [T]he fundamental objects of physics are no longer the trajectories . . . but probabilities. . . . [T]he simplest probabilistic processes are oriented in time [Prigogine 1996, pp. 85-86].

But this indeterminism, is supposed to be controllable. He writes:

> The indeterminism defended by Whitehead, Bergson, or Popper . . . has already imposed itself in physics. But it must not be confused with the absence of predictability, which would render illusory any human action. The issue is the limit to predictability [Prigogine 1996, p. 127].

The belief that his work on chemistry could be applied to social theory dates from the 1970s:

> The research conducted with my friend R. Herman on the theory of car traffic confirmed for me the supposition that even human behavior, with all its complexity, would eventually be susceptible to mathematical formulation. . . . [Prigogine Autobiography 1977].

How much of human behavior Prigogine believes can be so "predetermined," he tell us in an interview:

> I think that this type of modelling contains very important elements applicable to how a society behaves. The activity of each individual in society has a repercussion on the others. In mathematical terms, it is a highly nonlinear system which is able to manifest certain coherent behavior: habits, schema, or work. . . . Such schema have to be thought of as an average. But there are always in a society elements which behave differently. . . . This leads necessarily to the idea of a dialectic mechanism based on the appearance of contradictions, and on the idea of qualitative changes due to the contradictions produced by the preceding system. If one considers a model of systems of human behavior, one sees that it has aspects which *appear* very similar to those which can be established for certain societies of insects . . . but that there are also specific elements, such as the *Imagination* [Spire, p. 24, emphasis added].

Prigogine and G. Nicolis had previously constructed such models for insect and for human societies, with the following conclusions:

> Humans develop permanently individual projects and desires. In fact, certain of these, are the result of expectations as to what the future may look like. . . . The difference between the wished for and the actual behaviors act, then, as a constraint of a new type, which, together with the environment, shapes the dynamic. One can then ask oneself whether, under such circumstances, the outcome can lead to a global optimum or if, on the contrary, each human system constitutes a unique realization of a complex stochastic process whose rules can in no way be designated in advance. In other words, is past experience sufficient to predict the future, or, on the contrary, is the limited capacity of forecasting the future itself the essence of the human adventure? [Prigogine and Nicolis, p. 305]

The authors answer:

> The essential message of dynamical modelling . . . is that the ability of societies to adapt is what allows their long-term survival and innovation [Prigogine and Nicolis, p. 310].

In the same interview cited above, Prigogine derives his theorem as an alternative to the economic theory of equilibrium:

> I think that now we have to take in consideration the character of the uncertain . . . and, with the uncertainty, the idea of risk, the idea of choice introduces itself. This

uncertainty is an integral part of the structure of the universe [Spire, p. 25].

Ruelle had mentioned that chaos theory, at best, is a "scientific philosophy." We have that same impression from Prigogine's models, which I synthesize as follows:

Imagination is the human form of an evolutionary or "vertical" feedback (the future in the present). This type of feedback, makes impossible any deterministic (mechanical) forecasting, and establishes societies as "uncertain" (chaotic), a property of the human subsystem which reflects a universal characteristic (universe).

In such subsystems, adaptation by some risk-filled choice is the rule for survival.

Or, using Prigogine's thermodynamics, one can conceive of "imagination" as a dissipative structure produced by the "arrow of time" (entropy). One feels impelled to sympathize with the striking university students in 1968 when they screamed, "power to imagination!"

Yet, although it sounds nice, this is of limited help to managers or governments who have, indeed, to take risks and make choices. Prigogine's alternative to the theory of economic equilibrium seems to me not even to match Joseph A. Schumpeter's theory of "innovation," although here I have to admit my ignorance of other economic texts by Prigogine.[18] But even if one were to add the term "innovation," this would not tell us much more.

What type of innovation? Beyond imagining, can we also judge the effect of our actions on the future? Or are our choices valueless? Can we steer our "creative impulse" a bit, or are we simply carried away by it, like happy babies? Can we foresee future catastrophes (no matter in how limited a way), and, more important, can we *avoid* them?

What can the proper organization of society contribute to the innovative drives—or can it? For me, these are some of the issues involved in "forecasting," and Prigogine tells us that he can forecast:

> What I wanted to show [in *La Fin des Certitudes*], is that if you think, not just about a situation, but about the set of situations, then you can *all foresee* [emphasis added]. To get the answer, then, one needs to generalize . . . the way in which one confronts the problem. . . . The central point of my book is this: In the extension of the notion of lawfulness, there arise many situations where one can only describe their history in terms of ensembles. This means that history is a global problem. . . . The future is not totally unpredictable, but neither is it certain [Spire, pp. 78-79].

Interesting, but, where are some examples of the theorems or policies that such a "global" approach produces? In Prigogine's book, we find only a methodological analogy with "population theory." He writes:

> Darwin showed that it is the study, not of individuals, but of populations over long periods of time, which allows us to understand how individual variability, submitted to a selective process, produces variation. Boltzmann, likewise, argued that one cannot understand the Second Law, and the spontaneous increase of entropy that it predicts, if one sticks to the description of individual dynamical trajectories. It is the innumerable collisions inside of a population of particles which produce the global variation described by the increase of entropy [Prigogine 1996, pp. 27-28].

Those are Prigogine's ideas and explanations. After all is said and done, there remains at least the hope that his work in chemistry will contribute to the solution of physical problems, such that we might not merely issue forecasts, but actually make our uncertain future a bit better for more people.

Conclusion[19]

In conclusion, I return to the crucial issue of the interplay between "vertical" and "horizontal" processes, addressed with different names by almost all the authors here analyzed. Whether it be by a "world line," or an "arrow of time," all are seeking a generalization and reunification of the paradoxical form of human knowledge, which includes three simultaneous sets of experiences:

(1) The process of extension in space and time ("horizontal" projection) of our "present" knowledge.

(2) The power, both outside and inside us, which changes the "present" manifold, creating a direction vaguely named, "time's arrow," "absolute time," "duration," "world-line," and so on. (That this process is both "outside" and "inside," generates an additional need for unification, and raises the questions: who directs whom; who measures whom; who judges whom; who is the real one, and so on?

(3) At each moment we actually have a unity of both processes, or better, each moment is actually an infinite unity of an "ensemble" of clearer or bigger unities of "past-present-future." This process can provoke either the joy or the terror of the imagined moment when it will seem that we know all and have nothing more to do.

Within the above bounds, all agree that there is a specificity in human societies, but it is nevertheless necessary to emphasize, that although it is the "species" which is conserved, its survival depends upon the activation of the inner, sovereign cognitive power residing within each individual among its members.

This individual process of validated discovery, because it is able to ensure a continuing and growing existence for society, reveals our participation in the underlying reality of the world. The act of discovery not only transcends the individual's momentary biological existence, but the more universal the act is, the more such a simple moment makes explicit the individual's participation in eternity, unveiling and giving value to the same presence in all human beings. This process of objectifying our subjective existence, or of humanization of the world, locates us "above" any given ecosystem, and can be named "Platonic realism."

Some chimpanzees make use of tools, either singly or in

18. We have followed the work of Georgescu Roegen, who uses Prigogine, but who arrives, in the end, at a pure ecologist economy!
19. I have used here some of the concepts of Lyndon H. LaRouche, Jr., which can be found in referenced works in the bibliography, and in the ongoing publication of his works in the weekly *Executive Intelligence Review*.

combination, and some can even transmit this acquired behavior. They try to rise, culturally, above the limits of the "ecosystem." But neither in the laboratory nor in nature, are they able to shape tools, or change behavior in such a way as to solve any *imagined* future problem. They only operate and respond to the present, sense-perception manifold; a female only transmits the acquired behavior to her young showing him how to " take *this* to do *that*." As Prigogine also recognizes, all animal species lack the peculiar sense of the "future acting upon the present." But the too-quick conclusion, that both cognition and imagination are equivalent kinds of action of the "future upon the present," can lead to a mistake, when applied to the study of the necessary condition for evolution.

To clarify this difference, we have to go back to Plato. From the example of the chimps, one should easily grasp why Plato stressed that an *"idea" is never "this or that"*; but to go deeper into the relation between "Platonic ideas" and the "future," let me quote Lyndon LaRouche:

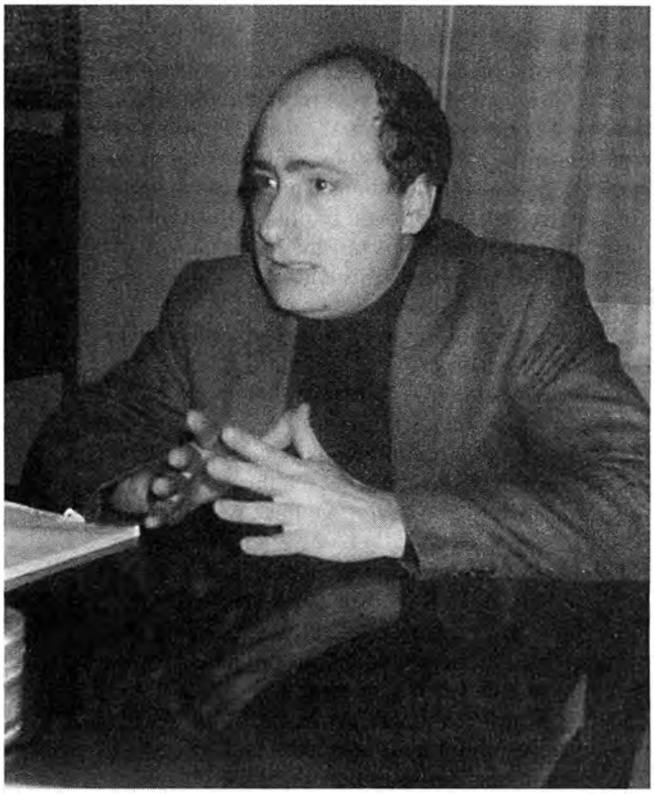
> [T]he relevant expression of human intent [is] a desired change in the axiomatic characteristic of some referenced pattern of human behavior. . . . What is desired is not a mere event, nor a mere change in opinion, but, rather either a change in hypothesis, or theorem.
>
> The change which distinguishes characteristically human ideas of the future. . . is always of the ontological quality designated by the connotations of the term Platonic Idea, rather than mere contemplation of a real or merely desired object of sense-perception [LaRouche 1996, p. 20].

We imagine, but we must above all *ensure* the future, through "ideas" which are needed the first moment one foresees a limiting paradox to a presently functioning hypothesis. Ideas are able to overcome the types of paradoxes which no deductive or linear extrapolation of present knowledge can, and unsolved paradoxes mostly result in physical catastrophes threatening the existence of entire societies.

The idea of constructing tools (and especially the mastery of fire) solved the first ecological "limit" our ancestors faced millions of years ago. For this reason, the power of an idea can be measured in terms of "potential," or by the degree to which the density of a population can rise *above* the limit defined by an ecosystem.

But, a materialized idea or hypothesis, as illustrated by Lazare Carnot's discoveries, is subject to entropy, which means that the potential cannot be maintained at any fixed value, as by recycling, deductive theorems, or any other purely quantitative increases. No such approach can avoid the nullification of the "aboveness," and our thus falling back to a level where physical nature is the only master. We have suffered many such falls in our history, but also some recoveries.

The uniqueness of human culture is expressed then, not by the production of one idea, but by the continuous generation of ideas which are able to conserve and *increase* the level of the "aboveness." Only this "humanization" of nature reflects the necessary condition of existence. The process is not mechanical nor mechanizable. We must be able to communicate the inborn, internal capability for generating cognitive discovery, from generation to generation. We must have a dialogue with the past, by reliving the cognitive acts of discovery of today's biologically dead, to rework their ideas; we must exchange ideas with our contemporaries, and must explain ourselves to the yet-to-be-born.



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Dino De Paoli: *"We must have a dialogue with the past, by reliving the cognitive acts of discovery of today's biologically dead, to rework their ideas; we must exchange ideas with our contemporaries, and must explain ourselves to the yet-to-be-born."*

Ideas take the form of atomized discontinuities, a quantum, a monad: before and after a real discovery, there is an eternity of distance, but if the "line" representing the conservation of our human world appears continuous, it is the result only of this possibility of being able to communicate ideas to each other.

LaRouche emphasizes that the power of a culture, lies in its having developed a classical "artistic" education, the unique instrument able to mediate a dialogue between minds. An education which evokes in the other, what is there, but still unused: the "Platonic ideas" needed to preserve and continue humanity's existence. There is no substitute for such education, based on the use of metaphor. If it is true that logic, when confronted with "ideas," can produce only symbolism, it is also true that we cannot leave ideas to the hopes of an unconscious intuition.

The Leonardos and Rembrandts of prehistoric times have left on the walls of caves in southern France and Spain, splendid examples of how to use humor and metaphor to educate—a humor which makes us laugh after 30,000 years, without need of any explanation. This is never true of the symbolic representation also present in artistic productions of that same era.

The internalized and the explicit representation of this "world line," this chain of monadic ideas, can now clearly become a general metric. From it, we can determine the "values" by which to compare choices and even "innovations"; not all innovations are able to increase or even maintain the "aboveness," the potential characteristic of the human societies. I wish to illustrate this with a concluding example.

We can "imagine" many futures, but let us select two cases based on present "hypothesis."

We know that there is *x* probability, that a meteorite could destroy the present form of life on Earth. Assume that our allowed reaction time, from the moment of discovery of such a threat, might be as short as two to five years. We have two possibilities:

Either, (a) we determine that we can solve (*avoid*) the problem, by application of present technical know-how, in which case we must define policies, now, to ensure that the maximum potential will be mobilizable when the strike comes.

Or, (b) we determine that we cannot meet the threat using technologies presently available to us. Then we must start *now* to maximize the possibility of a "creative" breakthrough which can bring us to the next, *higher* level of technical know-how.

Suppose that we now extend the timespan, but also the power of this example, as follows: In all probability, our Earth will be destroyed by an explosion of our Sun some 3 to 5 billion years from now. *What are we already doing,* to generate the idea necessary to postpone, if not to avoid, that tragedy?

From the perspective of the above cited crises of existence, I can conclude that:

(1) Prigogine's thesis essentially comes down to this: To be creative, one needs uncertainty. Knowing of a future crisis does not prevent creativity, however. On the contrary, it must stimulate us to find a creative solution.

(2) Innovations in windmill technology, for example, are not valuable innovations today.

(3) We are the only element in the system Earth, with an infinitesimal chance of overcoming these indicated limits. Thus, we are the only ones who bear the responsibility of helping life to survive.

(4) All the above is true, if and only if, we accept a simple axiom: *Existence* is not optional; it has a sufficient reason; it must and can endure.

Dino De Paoli, based in Hannover, Germany, has written widely on the history of science. Sponsored by the Schiller Institute, he has recently presented a series of lectures to university audiences in Europe on the ideas in this article.

J. Plassard, *Rouffignac* (Stuttgart: Jan Thorbecke Verlag, 1999)

"The Leonardos and Rembrandts of prehistoric times have left on the walls of caves in southern France and Spain, splendid examples of how to use humor and metaphor to educate—a humor which makes us laugh after 30,000 years, without need of any explanation." Here, a painting of a laughing horse or bison (ca. 14,000-15,000 years before present), from the Rouffignac cave in France.

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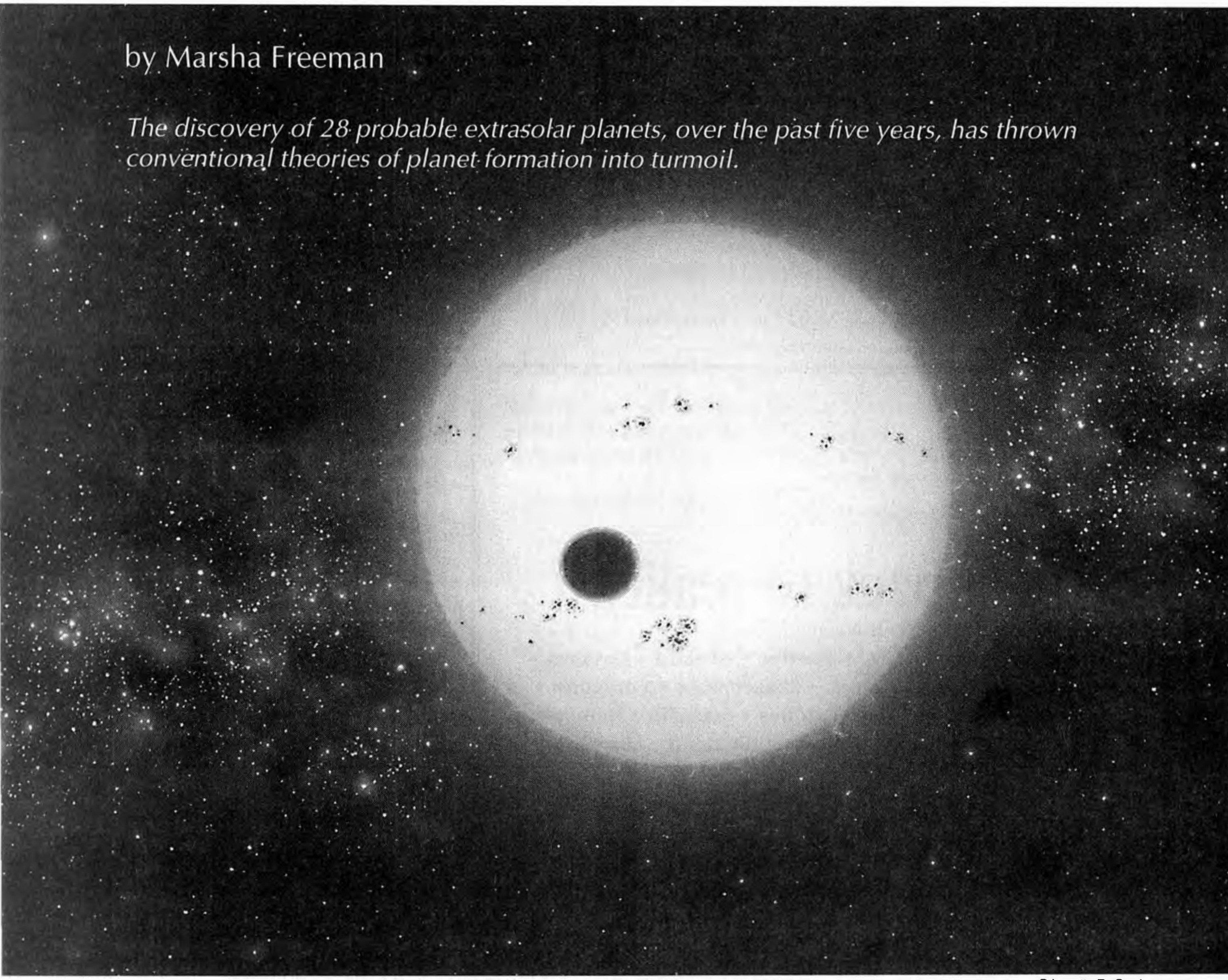
The Growing Evidence Of Planets Beyond Our Solar System

by Marsha Freeman

The discovery of 28 probable extrasolar planets, over the past five years, has thrown conventional theories of planet formation into turmoil.



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An artist's illustration of what the transit of a planet around star HD 209458 might look like. The planet, which was detected by astronomers Geoffrey Marcy and Paul Butler, is a Jupiter-like gas giant.

Are there planets orbiting stars outside our Solar System? Is it possible that life could have developed on any of these planets? Until just a few years ago, these age-old questions could be asked, but they could not be answered. Over the past five years, however, astronomers have detected what appear to be 28 planets orbiting other stars. They *appear* so because they cannot be seen directly: At today's level of technology, they are too far away and too small, and are too overshadowed by the light of their host star, to have their picture taken. Their existence is inferred from indirect data, which measure the effect the planet has on its star. But no one can explain how they formed and why they are where they are.

So far, because of the limits of the instruments used, the planets that have been detected have been inferred to be huge gas giants, similar in size to Jupiter. These gas giant planets seem to bear little resemblance to the organization of planets in our Solar System. In most cases, they orbit closer to their star than Mercury does to the Sun. Stranger still, they appear to be in markedly elliptical orbits, rather than the virtually circular ones with which we are familiar.

These striking differences between what we can see in the Earth's neighborhood, and what we are finding in other planetary systems, has directly challenged the conventional theories of planet formation. Scientists had assumed that were they to find other solar systems, such systems would conform, at least in basic parameters, to our own. Dr. Geoffrey Marcy, one of the most successful and determined planet finders says, "there's been a dramatic sea change in our thinking about the formation and the evolution of planetary systems." He describes the change as "dramatic, even philosophical."[1]

To meet the scientific challenge of finding "new Earths," techniques are being developed for applications both with telescopes on the ground and with those that will be placed into space. These will soon extend the ability of astronomers to detect smaller planetary bodies, and to determine the composition and characteristics of the smaller planets, as well as those of the gas giants. Over the next decade, we may indeed actually find new Earths.

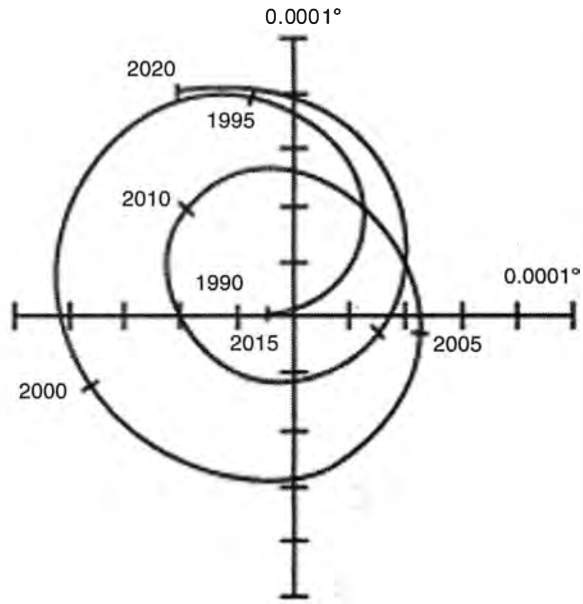


Figure 1
ASTROMETRIC DISPLACEMENT OF THE SUN
If an observer viewed the Sun from about 30 light years from Earth, this is the pattern of motion he would see between the years 1990 and 2020, the result of Jupiter's effect on the star. This "wobble" in a star's motion is the object of study using the astrometric method of detecting extrasolar planets.

Source: Jet Propulsion Laboratory/NASA

Searching for a Wobble

The search for companion bodies around other stars has a long, and sometimes disappointing, history. Astronomers well knew that it would not be possible to see a planet orbiting a star. The visible light of a star would completely overwhelm any light the planet might reflect back into space, the star being typically between 1 million and 10 billion times brighter than any companion. In addition, any planet would be so relatively close to its star, that even with today's level of precision observational technology, producing a separate image is impossible.

For centuries, scientists have known that bodies orbiting a star will produce perturbations in the regular motion of that star. In our Solar System, for example, not only do each of the planets orbit around the Sun, but the Sun is affected by the presence of the planets, which cause it to orbit in a circle with a radius of approximately 432,300 miles around the center of mass of the Solar System. The planet Jupiter, which has the largest mass among the planets—only 1,000 times less than that of the Sun—exerts the greatest perturbation on the motion of the Sun. It is that "wobble" in the Sun's orbit caused by companion planets, observable as a change in its velocity, that astronomers first set out to measure around other stars. This is known as the *astrometric* method of planetary detection. (See Figure 1.)

The first attempts to detect such a solar wobble were in the mid-19th century. The most fruitful targets were thought to be the brightest stars closest to the observer on Earth, because the effect being searched for was such an excruciatingly small deviation in the motion of the star. Within the limits of telescopes, the observer could expect to find only large, Jupiter-like planets, which, if they followed the pattern in our Solar System, would take at least a decade to complete their journey around the star—as does Jupiter. Smaller-orbit planets would not be observable, it was found, because the "noise" created by the Earth's own celestial motions would mask any tiny wobble that could be observed in the motion of the distant star.

This meant that decades of observations were required, in order to observe a full rotation of a star as it was perturbed by the planet's orbit around it. Patience has been one of the primary prerequisites in searching for extrasolar planets.

Dr. Alan Boss, a research scientist at the Carnegie Institution in Washington, D.C. has presented an engrossing review of the history of planetary searches,[2] in which he reports that, in 1844, the German astronomer Friedrich Wilhelm Bessel found that Sirius exhibited a wobble, characteristic of a star with an unseen companion. This companion was later unmasked by American astronomer Alvan G. Clark in 1862, using the largest telescope ever built (quite a feat in the midst of the Civil War), and was found to be a faint star, giving off less than a thousandth the light emitted by what was known, from then on, as Sirius A.

The next major advance came from Peter van de Kamp, an astronomy professor at Swarthmore College and Director of the college's Sproul Observatory, who dedicated decades of his life to finding unseen stars, and perhaps, extrasolar planets. In 1963, van de Kamp announced that he had found the first extrasolar body, orbiting Barnard's star. Edward Emerson Barnard (for whom the star is named) had noted that this bright star moved across the sky past its neighboring stars, in images taken during the 22-year interval between 1894 and 1916, indicating an unseen companion.

Van de Kamp did a meticulous comparison between the 1916 images of the location of Barnard's star, and the years of observations he himself made, starting in 1938. Dr. Boss reports that by taking about 100 photographs of Barnard's star each year, between 1938 and 1963, van de Kamp amassed an archive of more than 2,400 images, taken by 50 different astronomers at the Sproul Observatory.

In 1963, van de Kamp announced to the scientific community his conclusion that Bernard's star was being orbited by an object with a mass that was 60 percent of the mass of Jupiter, leading him to believe that he had found the first extrasolar planet. Careful analysis of the decades of data implied that the planet orbited the star once every 24 years, twice the period of Jupiter's orbit. But that was not the end of the story.

One disturbing feature of van de Kamp's discovery was that the orbit derived for the companion of Barnard's star was highly elliptical, unlike any in our Solar System. In 1969, therefore, he offered an alternative explanation for his data, stating that two planets in circular orbits could fit the observations, just as well as one larger planet in a highly elliptical orbit.

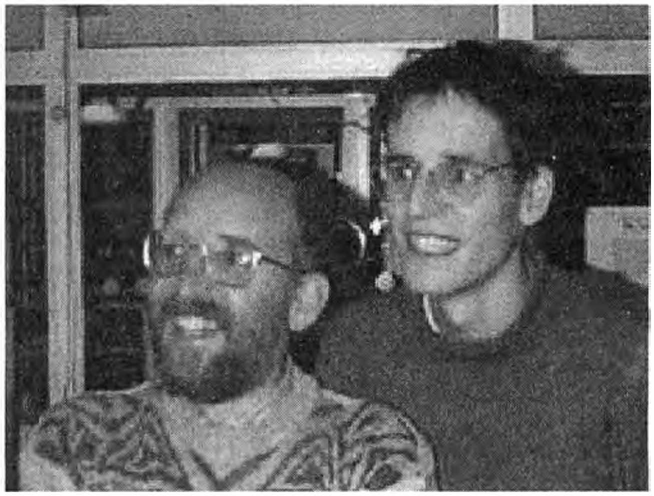
Four years later, however, astronomer John L. Hershey, who made observations of another star, over many years at the same Sproul Observatory, found the same perturbations in that star's orbit as were found in the companion to Barnard's star—an impossible coincidence. Careful investigation then determined that the irregular motion of these stars could be attributed to adjustments in the lens of the telescope, and were simply artifacts of the hardware being used.

Even more damaging evidence came from another team of astronomers, which was observing Barnard's star in order to try to confirm van de Kamp's extrasolar planets. This team examined the photographic plates from different observatories, using a more precise astrometric analysis, and found that there were no planets orbiting the star.

Although van de Kamp's companion did not survive the scrutiny of more careful analysis and improved technique, its initial announcement, and the activity that it generated, helped propel into scientific view the possibility that ground-based astronomical techniques could be applied to search the heavens for other stars with companions, like our Sun.

The Shifting Light of Stars

As the hunt for extrasolar planets picked up speed, a new technique was brought into the arsenal of the hunters. In 1988, Dr. David Latham announced that there was evidence of a "planet" in orbit around the star HD114762. He did not come to this conclusion using astrometric data of optical observations of the position and movement of the star, but instead used the changes in the frequencies of the star's emitted light. This technique measures the radial velocity of the star, using spectroscopy to study its spectrum.



Swiss astronomers Michel Mayor (left) and Didier Queloz stunned the world in 1995, with their announcement that they had found the first extrasolar planet.

In 1842, Austrian physicist Christian Johann Doppler discovered that the frequency of sound waves, as perceived by an observer, changes as the object emitting the sound changes its velocity. The same effect is observed in light waves. The perceived shift in the frequency of the light is either toward the shorter wavelengths (blue shifts) or longer wavelengths (red shifts), depending upon whether the object is moving closer to the observer or farther away. (See Figure 2.)

Dr. Latham observed the change in the spectrum of the star, reflecting the velocity of the star in its orbit. The spectrum of star HD114762 appeared to be alternatively red- and blue-shifted by the same amount in each direction, periodically. This shift was interpreted as a result of the orbit of the star moving toward and away from the observer on Earth, as would be expected of a body that is in a regular orbit of constant velocity, where the angle of observation is as close to that of the planet as the star's orbit.

The object that Dr. Latham found was inferred to have a mass equal to perhaps 11 Jupiter masses. He initially believed it to be a planet, but then recognized it to be in the category of a brown dwarf—a star that did not have enough mass to ignite stellar thermonuclear reactions.

It was not until the late 1980s, that the use of spectrometers had reached the level of precision where such fractional changes in the motion-induced frequency of a star's light—as small as 1 part in 100 million—could be measured. It quickly became the preferred method of hunting for extrasolar planets by teams of astronomers around the world, all of whom were anxious to be the first to find such new Earths.

The breakthrough came in 1995. In the beginning of that year, Dr. Geoffrey Marcy, a professor at San Francisco State University, sent an e-mail, indicating his optimism in finding

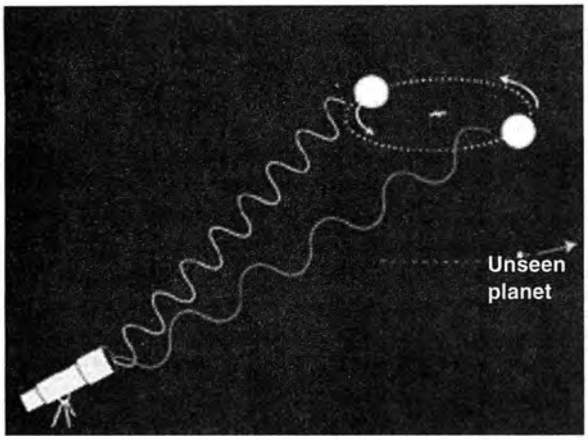


Figure 2
DETECTING THE DOPPLER SHIFT FROM STELLAR VELOCITY

In addition to trying to measure the motion of a star directly, the changes in the spectrum of a star's light (Doppler shift), caused by the effect of an unseen companion, can be measured as it moves in an orbit. The spectrum of light emitted by the star when it is moving toward the observing telescope will compress the light waves and shift the light toward the blue end of the spectrum. As the star moves away from the observer, the wavelength decreases, and the light is shifted toward the red.

Source: Courtesy of Geoffrey Marcy and Paul Butler

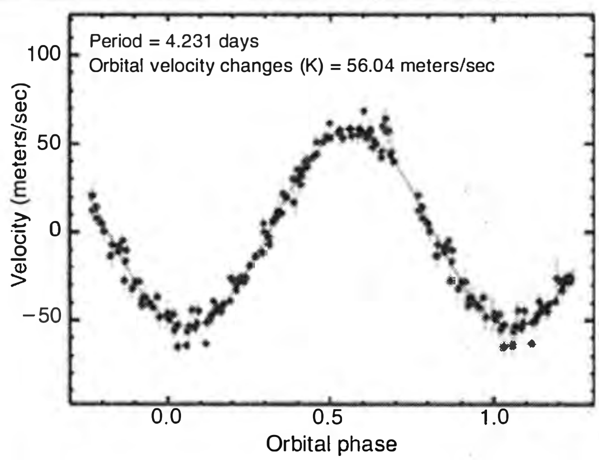


Figure 3
DOPPLER MEASUREMENTS FOR 51 PEGASUS

Measurements made at the Lick Observatory by Michel Mayor and Didier Queloz, between Oct. 11, 1995, and December 1996, revealed a periodic change in the velocity of the star. The period was determined to be 4.231 days, and the orbital velocity changes were determined to be about 56 meters per second. It was the first detection of an extrasolar planet.

Source: Courtesy of Geoffrey Marcy and Paul Butler

Jupiter-sized planets around other stars. Dr. Boss reports that Marcy, along with collaborator Paul Butler, had developed an improved spectroscopic technique, which Dr. Marcy was confident would allow them to detect Jupiter-sized planets. He reported to Dr. Boss that he was able to measure the velocities of candidate stars within a few meters per second, the pace of a brisk walk. Because Jupiter's effect on the Sun clocked in at 13 meters per second, extrasolar planet detection on the Jupiter scale should be possible. (By comparison, the size and mass of the Earth introduces only a 9-centimeter-per-second oscillation in the Sun's motion.)

The spectroscopic method is best suited for the detection of Jupiter-type planets close to their star, where such planets would have the greatest effect on the star's velocity, most easily detected by Doppler shift. For greater distances, the astrometric method is better suited, because the farther away the planet is from the star, the greater is the wobble in the star's orbit.

Planetary searches were also being carried out outside of the United States. In October 1995, Swiss astronomer Michel Mayor stunned the scientific community by making the announcement at a scientific conference in Italy, that he and his colleague Didier Queloz had determined that the star 51 Pegasi, a star similar to the Sun and about 45 light years away, hosted a half-Jupiter sized planet. (See Figure 3.)

As stunning to the astronomers as the first detection of an extrasolar planet, was the fact that the planet appeared to be so close to the star that it was orbiting once every 4.23 days—a far cry from the nearly 12 years it takes Jupiter to orbit the Sun. Such an orbital period would place the planet at a distance to its star that was 100 times closer than Jupiter is to the Sun, or closer than Mercury is to the Sun. No one had ever imagined that an icy gas giant could be created so close to a star.

Considering the history of false starts and later-discarded claims of extrasolar planets, other teams of astronomers were anxious to see if Mayor and Queloz's detection could be confirmed. As Dr. Boss describes it, "if the discovery could not be confirmed, the Swiss claim might have to be tossed onto the heaping pile of previous failed dreams."

That confirmation came within two weeks, from the team of Geoffrey Marcy and Paul Butler, who were soon to become the most prolific planet hunters in the world. It was the first time that two independent teams of astronomers had produced data from which they could conclude that a planet was orbiting around a solar-like star. Now that there was confidence that extrasolar planets do indeed exist, the race was on to survey the most promising stars, and to determine how many possible companion Jupiters there might be.

After all, if there were Jupiter-like planets around other stars, could there not be other Earths?

A Solar System *Unlike* Our Own

Between 1995 and 1998, 18 candidate extrasolar planets were detected. Although 1999 would turn out to be a banner year for finding these stellar companions, the mystery of how these planets formed, and why they appear to be so different than the family of planets that are so familiar, had deepened.

In 1996, Drs. Marcy and Butler detected a planet orbiting the star Upsilon Andromedae, which star is visible with the naked eye from the Northern Hemisphere, and is about 44

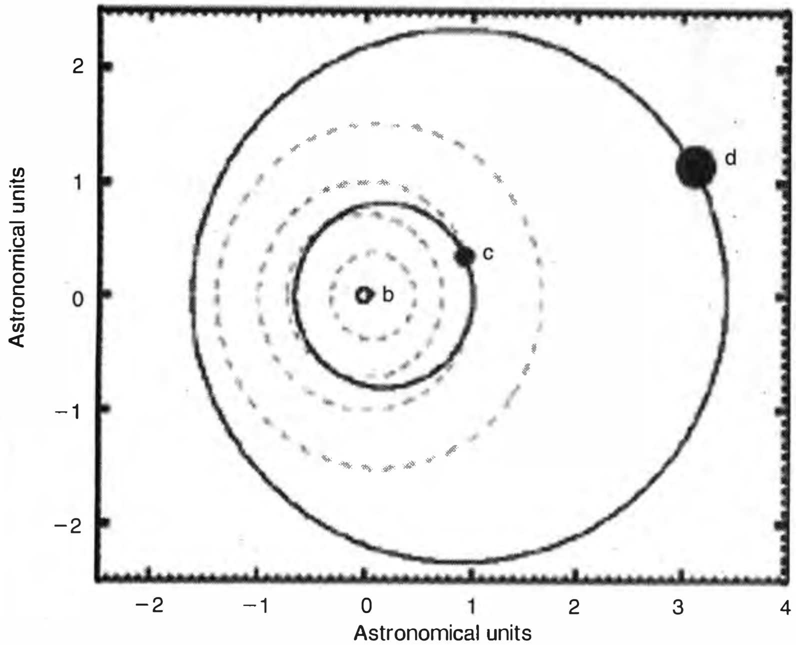
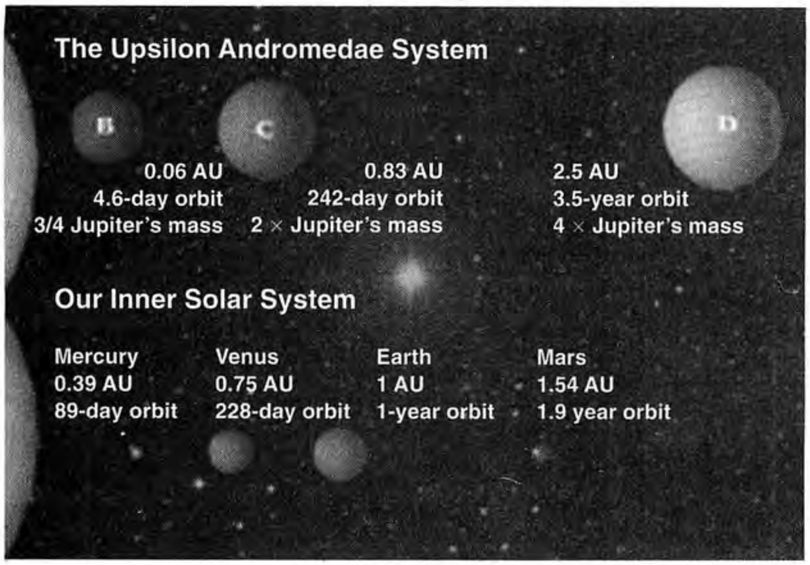


Figure 4
THE FIRST MULTI-PLANET SYSTEM: UPSILON ANDROMEDAE
(a) The three planets detected around the star Upsilon Andromedae, designated as b, c, and d, are the first discovery of a multi-planet system outside the Solar System. The planets are in progressively more elliptical orbits as their distance from the star increases. The orbits of Venus, Earth, and Mars in our Solar System are shown in dashed lines, in order to highlight the eccentricity of Upsilon Andromedae's planets.

Source: Courtesy of Geoffrey Marcy and Paul Butler



(b) Another look at the three bodies orbiting the star Upsilon Andromedae Most striking is the difference between these planets and those in our Solar System. The two smaller planets (b and c) are closer to their star than the Earth is to the Sun, and all are in the Jupiter-class in terms of mass.

Source: Adapted from illustration by A. Contos/Harvard-Smithsonian Center for Astrophysics

light years from Earth. The planet was estimated to be approximately three quarters of the mass of Jupiter, and a distance from the star of only 5.5 million miles, completing an orbit every 4.6 days.

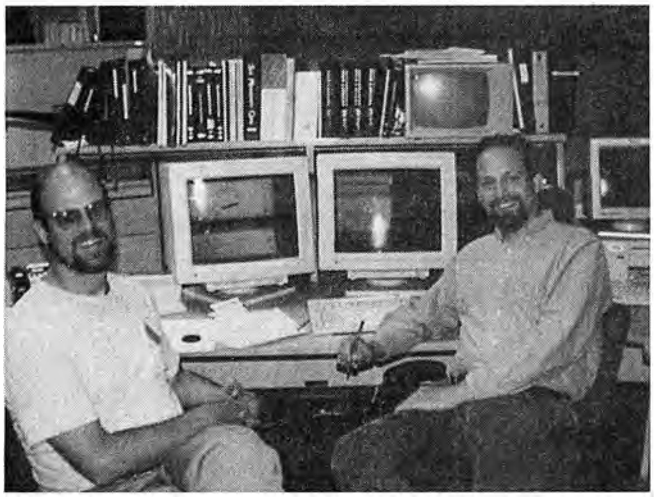
Then, three years later, a stunning discovery was made. In April 1999, Marcy and Butler announced that the further analysis of data from 11 years of observations of Upsilon Andromedae, taken at the Lick Observatory near San Francisco, revealed that there were *two more* planets orbiting the same star. And in parallel, a team of astronomers from the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, and the High Altitude Observatory in Boulder, Colorado, also found the two outer planets around Upsilon Andromedae. The first extrasolar planetary system had been unveiled. (See Figure 4.)

When the news of the discovery was released on April 15, Debra Fischer, part of the Butler/Marcy team at San Francisco State University, remarked: "This is an extraordinary finding and it demands extraordinary evidence. Having two completely independent sets of observations gives us confidence in this detection." The chance of two independent groups finding the trio of planets, "happening by accident are infinitesmal," she said.

The discovery of three Jupiter-sized planets around one star baffled the scientists who found them. "I am mystified at how such a system of Jupiter-like planets might have been created," co-discoverer Geoffrey Marcy said at the time. Robert Noyes, a professor of astronomy at the Harvard-Smithsonian Center for Astrophysics, commented: "This will shake up the theory of planet formation."

Timothy Brown of the High Altitude Observatory explained that "the usual picture is that gas giant planets can only form at least four AU [Astronomical Units, the distance between the Earth and Sun, or about 93 million miles] away from a star, where temperatures are low enough for ice to condense and begin the process of planet formation. But all three giant planets around Upsilon Andromedae now reside inside this theoretical ice boundary."

In a paper by members of both teams of observers submitted to the *Astrophys-*



Courtesy of Paul Butler and Geoffrey Marcy

Paul Butler and Geoffrey Marcy have been the most prolific planet finders. Dr. Butler is currently at the Carnegie Institution Department of Terrestrial Magnetism in Washington, D.C., and Dr. Marcy is now at the University of California at Berkeley.

ical Journal, the scientists describe their precision Doppler velocity method as requiring a minimum of seven of the light frequency shifts to describe the orbit of a planet, although 20 measurements, spread over more than one orbital period, are typically required to reliably determine the orbital parameters of the body. The fact that the orbital period of the outmost, "d" planet is about 3.5 years, requiring observations over that time period, indicates why it was not precisely located at the time the first 4.6-day period planet was determined.

The authors point out that the fact that the two outer planets of Upsilon Andromedae follow elliptical orbits is not entirely unexpected, because half of the approximately 20 extrasolar planets that had been detected by that time, which were orbiting more than 0.2 AU from their stars, also had significant eccentricities in their orbits.

Almost all theories of planetary formation developed before the discoveries of extrasolar planets assumed that all planets would be in near-circular orbits, similar to the architecture of our Solar System. They also assumed that gas giant planets could reside only in the outer system of planets. Now, theory was in turmoil.

Finally, a Confirmation

The confidence astronomers have had in their detections of extrasolar planets has varied, because of the difficulty, and indirectness, of the methods used in the search. Many of the finds are characterized as "candidates," awaiting more data and confirmation. Although the multi-planet system orbiting Upsilon Andromedae was calculated by two different teams of astronomers, both used Doppler velocity measurements to come to their conclusions.

Are there other techniques that can be used to find these elusive planets?

One such proposed method is microlensing, or making use of the effect that one star has on another star's light when both are precisely aligned in the line of sight of the observer on Earth (See Figure 5).

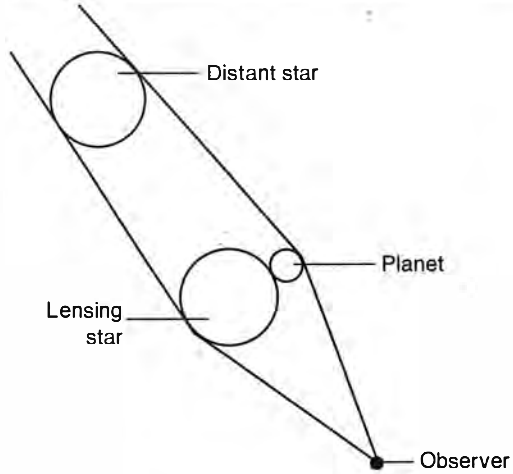


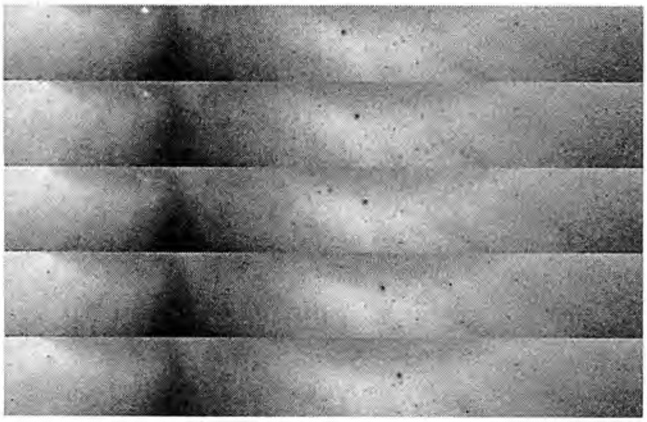
Figure 5
THE METHOD OF GRAVITATIONAL MICROLENSING

Using microlensing to indirectly detect a stellar companion depends upon the chance alignment of two stars, making the observation difficult to repeat or verify. When a star with a companion aligns in the line of sight of the observer with a more distant star, the light of the distant star is distorted because of the gravity of the nearer star. This can cause the light to be focussed, and the more distant star to temporarily appear brighter. If there is a planet around the star, this effect will be intensified.

In this case, the gravity of the lensing star bends the light of a more distant star, focussing the light and causing the more distant star to brighten. If the closer, lensing star is accompanied by a planet, the lensing effect will be more pronounced. But unlike the measurements that can be taken with the astrometric and spectrographic techniques (which result from regular planetary motion, such as the orbit around the star, and can be repeated with each period of revolution), microlensing depends more or less on a "chance" geometric relationship between a nearby and distant star.

This creates a serious problem for using the microlensing method to detect extrasolar planets. As Donald Goldsmith explains in his book, *Worlds Unnumbered,* "the geometrical requirement that an object pass almost directly between ourselves and a star make gravitational microlensing extremely unlikely."[3] Astronomers have developed ways of extending their search for this unusual geometric line-up among celestial objects, to the extent that many millions of stars could be surveyed in one night. But there appears to be no solution for the second problem of microlensing—repeatability.

On Nov. 3, 1999, the members of the Microlensing Planet Search project, led by David Bennett and Sun Hong Rhie at the University of Notre Dame in South Bend, Indiana, reported that using the microlensing technique, they may have found evidence of the first known planet orbiting a pair of stars. Because at least half of the stars nearest the Earth are binary stars, it was hoped that the possibility of finding extrasolar planets would be greatly increased. The observations were



Courtesy of Goddard Space Flight Center/NASA

This series of X-ray images was recorded by the Soft X-ray Telescope on board the Japanese Yohkoh satellite in November 1999. It captures the transit of the planet Mercury across the face of the Sun. The movement of the small planet can be seen from top (just to right of center) to bottom, moving west to east. The dark patch is a coronal hole near the solar south pole.

made at the Mount Stromlo Observatory in Australia, the Wise Observatory in Israel, and the Cerro-Tololo Inter-American Observatory in Chile.

When Bennett and his group announced their findings, other astronomers proposed that alternative models could also fit the data. Dr. Paul Butler stated in a recent interview, "There is little or no confidence in the interpretation of these observations."[4] Dr. Butler explained that while the group reporting the find "claimed they needed a planet and a binary star to fit the microlensing data, the competing microlensing group 'PLANET,' showed they could fit the data better with just a binary star system that included the orbital motion of the two stars during the lensing event."

Very little is revealed about the supposed planet detected through microlensing, and "we don't know what kind of a star the planet was orbiting, because the star is never seen in a lensing event," Dr. Marcy explained in an interview. The star that is being observed is extremely far away, he said, "thousands of light years. The intervening planet between us and that star is also probably approximately 1,000 light years away. As a result, our most powerful telescopes can't detect the planet at all."

The fact that once the two stars moved out of alignment the observation could not be repeated made the finding a mystery; there is no way to verify an observation. "The challenge in the microlensing technique," Dr. Marcy explained, "is to provide detections that are so secure that a follow-up effort is not necessary, and that is a difficult challenge in science."

Less than two days after the Microlensing Planet Search report was made, a truly dramatic announcement was made—the first confirmation of an extrasolar planet. On Nov. 5, 1999, Geoff Marcy, Paul Butler, and Steve Vogt discovered a planet orbiting the star HD 209458, while observing at the W.M. Keck Observatory in Hawaii. HD 209458 is a Sun-like star, 153 light years from the Earth. From their velocity/Doppler data, the astronomers determined that the planet was about five-eighths the mass of Jupiter, orbiting very close to the star, once every 3.5 days.

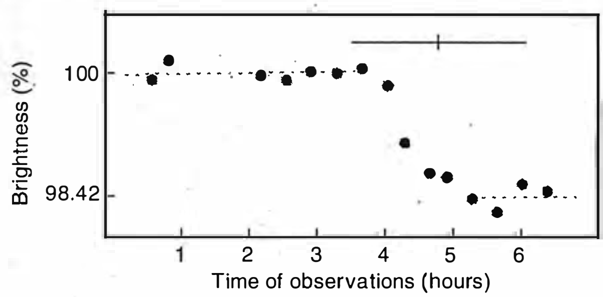


Figure 6
THE FIRST CONFIRMATION OF AN EXTRASOLAR PLANET

Photometric observations on Nov. 7, 1999, measuring the light emitted by a star, were used by astronomer Greg Henry to confirm the detection of an extrasolar planet, as it transited across the face of star HD 209458. At the onset of transit, a small but discernible dip of about 1.58 percent in the star's light, at the predicted time of transit, confirmed the detection of the planet made previously by Marcy and Butler, using Doppler radial velocity data.

Source: Tennessee State University

The team notified another astronomer (a procedure they always followed), Greg Henry, of the Tennessee State University Center of Excellence in Information Systems. Dr. Henry operates a set of automated telescopes at Fairborn Observatory in Arizona. Dr. Marcy hoped that Dr. Henry would be able to observe a transit of the planet across the star, just as transits of Mercury and Venus across the face of the Sun are visible periodically from Earth. No transits of extrasolar planets had been previously observed.

In order for a transit to be visible from Earth, the orbital plane of the planet would have to bring it between the Earth and the star. Until that point, none of the other 18 planets Marcy and Butler had detected and referred to Henry—or any of the planets discovered by others—apparently had had this edge-on orientation toward the Earth.

Dr. Henry trained one of his telescopes on the star at the precise time that Drs. Marcy and Butler had predicted that the planet would transit the star, and, on Nov. 7, Henry reported that he observed a 1.58 percent dip in the brightness of the star, as the planet created a shadow when it passed across the star. (See Figure 6.) Because the planet is in a 3.5-day orbit, and, therefore, crosses in front of the star every few days, the transit was observed repeatedly over the next few weeks. This was the first independent confirmation of the existence of an extrasolar planet.

Two more transits of the planet were also observed by another team of astronomers—David Charbonneau of Harvard University, and Timothy Brown of the National Center for Atmospheric Research's High Altitude Observatory.

"The transit allows us to directly calculate the diameter of the planet, and to determine the 'sin *i*' the orbital inclination," Dr. Butler explained. "We thus learned the true mass of the planet, and the density of the planet. This is the first time that the orbital inclination and the density have been determined for an extrasolar planet. The new information is consistent with the planet having a 'Jupiter-like' composition, primarily hydrogen and helium."

In the case of star HD 209458, it is estimated that the planet is only 63 percent of the mass of Jupiter, and its radius is 60 percent larger than that of Jupiter, making it a kind of "bloated" planet. With a density of about 0.2 grams per cubic centimeter, it is a Jupiter-like gas giant.

Dr. Butler viewed the transit confirmation as removing any of the "ambiguity" that had existed about the reality of extrasolar planets. He also explained that when the planet moves in front of the star, some of the star's light passes through the planet's atmosphere on its way to the observer on Earth. The star's light spectrum thus contains an imprint of the planetary companion. If, in the future, the researchers can "tease" that information from the light of the star, it would be possible to determine what the planet is made of.

Dr. Marcy reported in February that the "star has set in the west, and is behind the Sun." The astronomers hope to do more observations of HD 209458 when it reappears in the spring and summer. He hopes that the new set of observations "will tell us the chemical composition of the planet and maybe a little more about its size, and even the spin rate of the star." Determining the spin rate of the star will be possible because of the blocking of some of the star's light by the transiting planet.

Dr. Marcy explained that because the star is spinning, when the planet crosses in front of the star, the planet blocks off the light coming from one edge of the star, and when it crosses to the other side, it blocks off the light from the other side of the star. Because the planet blocks off the light from the edge that is moving toward Earth as it spins, the remaining light we observe is the normal light from the star, minus the portion of the light that would have been coming toward us, which is now blocked by the planet.

Later, when the planet crosses the disk of the star, the other, trailing edge of the star, that is moving away from us, is blocked by the transiting planet. At that point, "we'll see one edge with the Doppler effect due to the gas on the surface of the star moving toward or away from us," he stated, "and that Doppler effect will tell us how fast the star is spinning, and which direction it is spinning in, because we know which edge of the star is moving away from us and which edge is moving toward us."

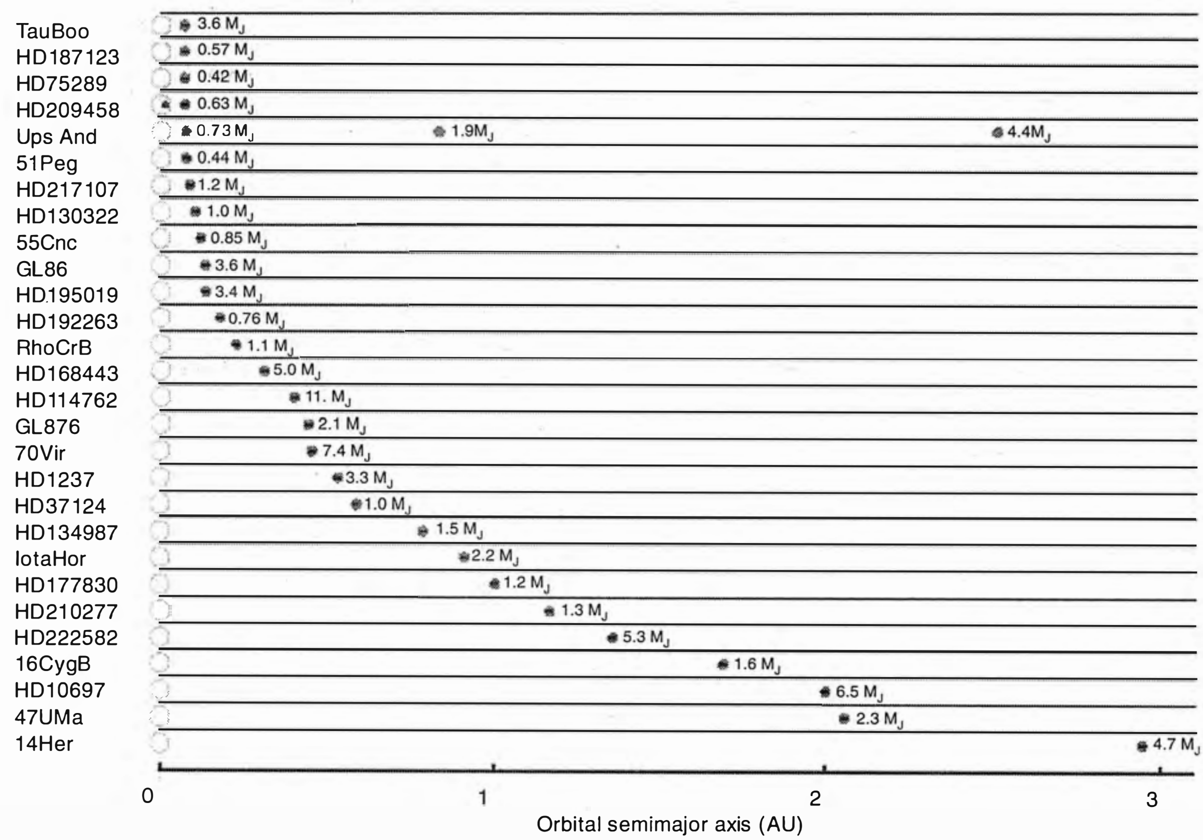


Figure 7
CATALOGUE OF EXTRASOLAR PLANETS, AS OF DECEMBER 1999
The 28 extrasolar planets discovered, as of the end of 1999, are listed here in order of inferred mass and orbital size. Mass is given in comparison to the planet Jupiter (M_J).

In the midst of the excitement over the first confirmation of an extrasolar planet, the Butler and Marcy team announced that they had also found six more extrasolar planets! At the end of 1999, the total cache of extrasolar planets stood at 28. (See Figure 7.)

All of these orbiting bodies are many times the size of the Earth. They are presumed to be gas giants, without the solid surface upon which life on Earth developed. The majority of them orbit so close to their host star, that no life as we know it could survive the searing temperatures. The one multi-planet system found so far, orbiting Upsilon Andromedae, "is about 10 times as massive as our Solar System. It's unlike anything we've ever seen before," confirmed Carnegie Institute theoretician Dr. Alan Boss.[5]

Drs. Marcy and Butler are continuing their observations, to try to help answer some of the questions. "We need to find more planetary systems around Sun-like stars," following the Upsilon Andromedae discovery, Dr. Marcy stated. "We have a few candidates in our data, and we are continuing to get more data and look specifically for planetary systems. We hope that we will have enough of them to do a real comparison with our own Solar System."

Second, the astronomers "hope to find planets that are not just Jupiter-mass, which we've been doing so far, but lower mass planets. Paul Butler and I," he reported, "have a very concerted effort to find planets that are as low a mass as Saturn, and even Neptune, the third biggest planet in our Solar System. That would be quite exciting, because we'd like to know if other planets elsewhere in the universe have the full range of masses, similar to the range that we have in our Solar System."

The team's third goal is to find planets that orbit "as far from their star as Jupiter orbits the Sun. We've only found Jupiters that are closer in. We want to find Jupiters that orbit far from their host star, because then those Jupiters will be directly comparable to the characteristic of our own Jupiter." They are also looking for such planets in a circular orbit, similar to that of Jupiter. Such a find could have an important impact on the question of life outside the Earth, because scientists now believe that a possible liquid ocean underneath the Jovian moon Europa may contain the conditions for the development of life.

New 'Eyes' for Telescopes

Even while constrained by the limits of existing technology, astronomers have made the astonishing discovery of worlds around other stars. Now they are on the threshold of employing new and more precise techniques to refine the observations already in hand, and expand the field of view that will lead to new discoveries.

There has always been great interest in searching for Earth-like planets outside of the Solar System, but the pace to develop the technology to do so has now quickened, since new Jupiter-sized planets have been found.

Dr. Roger Angel, an astronomer at the University of Arizona and an expert at building telescope mirrors,[6] has developed a variety of proposals to enable ground-based planetary searches with quality that is nearly space-based. (Dr. Boss remarked in an interview, "If you could give Roger Angel $20 million, he'd go out and build something really fantastic.")

One such proposal is to fit ground-based telescopes with

Tennessee State University

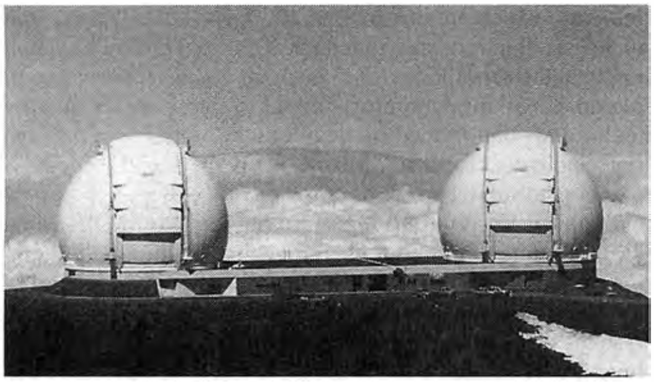
Dr. Greg Henry used this 0.8 meter telescope to observe the planetary transit of star HD 209458 in November 1999. He was able to confirm the planet's existence, using the photometric dimming of the star as the planet crossed its face.

adaptive optics, and thus enable them to begin to rival the performance of space-based telescopes that are placed above the blurring effects of the Earth's atmosphere. Adaptive optics have already been under development by the military over the past 20 years, one application being for ground-based laser systems that would be used for a beam weapon defense system.

Adaptive optics would remove the distortion in a star's (or a planet's) light as it passes through the atmosphere, by measuring the distortion in the wavefront of the light, and immediately compensating in real time by the superimposition of an equal and opposite aberration. The correction is made before the light is brought to a focus, by reflecting it on a small mirror, whose shape can be rapidly deformed, depending upon the correction required.

Dr. Angel has proposed that the sharp images possible using this method would allow the direct optical detection of Jupiter-sized planets, if not those down to an Earth-sized planet around close stars.

Dr. Angel, and his collaborator Neville J. Woolf, have recently pointed out that "taking photographs, however, is not the best way to study distant planets." Certainly in the search for Earth-like planets that might harbor life, no photographs we can conceive of taking over such long distances will show us living creatures. Aside from the artifacts we have built, there would be no evidence of life on Earth visible in photo-



Jet Propulsion Laboratory/NASA

The twin 10-meter telescopes at the Keck Observatory in Hawaii, with the island of Maui seen in the background. These telescopes, along with four accompanying smaller outrigger telescopes, are being prepared to make interferometric measurements of the wobble in the motion of a star. The scale will be comparable to detecting movement of 1 inch at the distance of the Moon. Observations will begin this summer.

graphs taken from as close as Earth orbit. Life on Earth, however, can be detected from space, through examination of the characteristics of the atmosphere, particularly the presence of oxygen, ozone, and methane.

To uncover the temperature, chemical composition, atmospheric pressure, and other vital characteristics of extrasolar planets, which will provide hints about the possibility of life, Dr. Angel proposes studying their reflected light using infrared spectroscopy, in the same way scientists learn about stars.

In 1986, Drs. Angel and Woolf proposed that the detection of signals at the mid-infrared wavelength, rather than that of visible light, would be the best spectral region in which to find planets and search for extraterrestrial life.[7] "This type of radiation—really the planet's radiated heat—has a wavelength 10 to 20 times longer than that of visible light," they explained. "At these wavelengths, a planet emits about 40 times as many photons—particles of light—as it does at shorter wavelengths. The nearby star would outshine the planet 'only' 10 million times, a ratio 1,000 times more favorable than that which red light offers."

But how do you magnify the emission of a planet to be able to separate it, and obtain a measurement distinct from its star?

Dr. Angel has proposed the use of interferometry—effectively, the combining of blurry images from two telescopes to produce one that has a higher resolution. The larger a telescope's collecting area, the more precise an image it can produce. But rather than making telescope mirrors larger and larger, it is possible to engage two telescopes (or more), separated by some distance, collect data from each, and precisely combine them to greatly improve the quality of the resulting image.

To increase the contrast between the bright star and less bright planet, Drs. Angel and Woolf proposed introducing a method developed in the 1970s by Ronald Bracewell of Stanford University. With two telescopes focussed on the same star, Bracewell found that he could invert the light waves from one, and then merge that inverted light with the light from the second telescope. If the peaks in the light wave precisely coincide with the troughs in the second, interference will cancel the propagation of the light.

This technique of "nulling interferometry" can be used to cancel the light being emitted from the star, while leaving the planet's radiation, which is emitted from a slightly different direction, still intact. In 1990, Dr. Angel proposed that the required precision would become possible, if more than two telescopes were deployed in the search. His proposals for transforming the search for extrasolar planets are now being implemented in ground-based telescopes, and will be applied to the instruments NASA is designing for the next steps in space.

The world's largest telescopes for optical and near-infrared astronomy are the twin 10-meter Keck telescopes on top of Mauna Kea in Hawaii. By combining the images from the two large telescopes, in conjunction with four proposed outrigger telescopes on the same site, scientists should be able to detect the wobble of a star of less than 1 inch at the distance of the Moon, or 3,000 kilometers at the distance of the nearest star. This would allow astronomers to detect planets as small as Uranus around a star that is 60 light years away, using the astrometric method of tracking the positions of the star.

The Keck Interferometer will also be used to make direct detections of infrared radiation from planets. The Interferometer will use simultaneous measurements at different wavelengths to subtract the stronger signal of the star. With this method, astronomers would expect to find large planets near their host stars, which have a high surface temperature. The Interferometer will allow the detection of "hot" planets, about the size of Jupiter, at a distance of 60 light years from Earth.

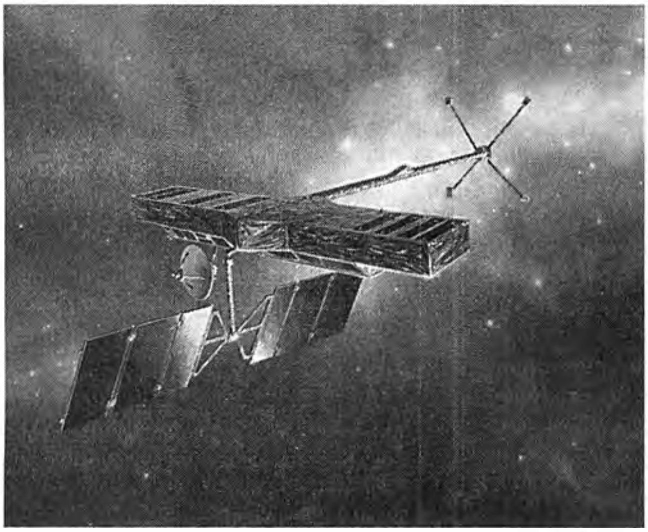
The current schedule is for the first phase of the Keck Interferometer to go on line in July 2000, with the addition of two outrigger telescopes. The second two outrigger telescopes will be ready in the spring of 2002. The Keck telescopes serve as a testbed for the technologies that will be the foundation of the ambitious, space-based projects under development.

Other ground-based facilities, such as the Large Binocular Telescope, are also expected to greatly expand the existing base of knowledge of extrasolar planets, and lay the basis for the remarkably precise instruments that are planned over the next decade.

The Planet Search from Space

To complement and extend the range of discoveries that will be possible over the next few years with new and upgraded ground-based observatories, NASA is planning a series of space-based missions as part of its Origins program. NASA Administrator Dan Goldin has challenged the scientific community to develop the techniques necessary to photograph an Earth-like planet around another star. Such an extremely difficult goal will be reached through a series of successive missions, over the next decade.

One very challenging mission, which would greatly extend the transit method of extrasolar planetary detection, is the proposed Kepler Mission, developed at the NASA Ames Research Center in California. The Kepler Mission will use the method of photometry, measuring the light of stars. It will continuously and simultaneously monitor the brightness of 100,000 stars, for the purpose of observing the dimming effect of planetary transits.



Jet Propulsion Laboratory/NASA

An artist's illustration of the Space Interferometry Mission. Scheduled for launch in 2006, the SIM will combine the data from its set of space-based telescopes to allow astronomers to detect multiple-Earth-sized planets around nearby stars, using radial velocity measurements observed in the shift in wavelength of the star's light. In this rendering, the eight telescopes are seen on the top of the spacecraft. The long boom to the right contains small mirrors that reflect back laser beams from the spacecraft, to measure the orientation of the telescopes.

The sensitivity of the photometer will be such that planets as small as 0.8 Earth radii can be detected, in or near the "habitable zone" of a wide variety of stars. The current understanding of the region in which a planet must lie to be able to support life is bounded by the range of distances from a star in which liquid water could exist on its surface. In our Solar System, this boundary is between 0.8 and 1.3 times the radius of the Earth. It is also estimated that for a planet to contain an Earth-like atmosphere, the mass of the body would lie between 0.5 and 2.0 Earth masses, large enough to maintain an atmosphere, but not so large that the atmosphere would be dominated by the lightest elements of hydrogen and helium.

The very definition of a "habitable zone," however, has undergone quite a bit of revision over the past few years. The announcement that the ALH84001 meteorite from Mars may contain evidence of past life there, and that the proposed ocean under Jupiter's moon Europa could possibly support the development of primitive life forms, has pushed the boundary for life considerably farther out than was previously believed.

Scientists have proposed a hypothesis that the four-year Kepler Mission could be expected to detect about 175 Earth-sized planets, about 425 large terrestrial detections; of these, it is thought that about 70 cases (12 percent) of the total would be multi-planet systems. They estimate that there is a 1/2 percent transit probability per planet in or near the habitable zone.

The Kepler Mission is conceived as a Discovery-class mission, which means that it would cost under $300 million, and would be ready to launch four years after it were selected. NASA has solicited proposals for the next round of Discovery missions, which are due in June 2000. The space agency will make its selections in November 2000. According to David Koch, at the Ames Research Center, the Kepler team has completed a working laboratory model to demonstrate that the technology can indeed be developed to monitor promising stars and detect Earth-sized extrasolar planets, and the team is planning to submit a proposal in the competition.

Kepler is designed to maintain a fixed stare at the same 100,000 stars throughout its four-year mission. It will, therefore, be looking largely at distant stars, deep into one part of the sky. The results from Kepler's watch could provide target systems that can be followed up by the next dedicated planet mission that is planned, the Space Interferometry Mission, or SIM.

The Space Interferometry Mission is currently scheduled for launch in 2006. It will be an optical interferometer, operating in the visible portion of the electromagnetic spectrum and designed for astrometric measurements. SIM will determine both the distances of stars and their positions, hundreds of times more accurately than any previous measurements. This will be accomplished by two telescopes at a maximum separation (baseline) of 10 meters, to record images of stars at a resolution several times higher than that of the Hubble Space Telescope. The spacecraft will also include two pairs of telescopes for precision pointing and orientation, and two spares that can be used either for science or pointing if there is a failure.

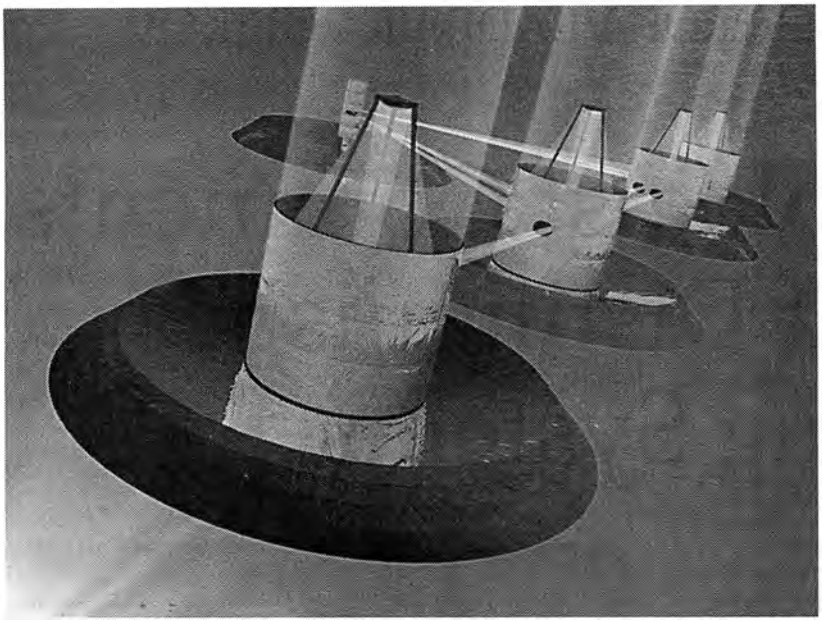
SIM will be able to detect large terrestrial planets (5 to 10 Earth masses) orbiting nearby stars. To accomplish this, over its five-year mission, SIM will search 200 main-sequence stars. Once a planet is detected through the "wobble" motion of its star, the search will be extended for evidence of additional planets in that system.

SIM will also demonstrate, for the first time in space, the technique of nulling. The interferometer can be tuned so that the light from the exact center of the field of view is blanked out, leaving any light from surrounding bodies to be imaged. The goal is to demonstrate this nulling capability, which will be critical for future missions, to 1 part in 10,0000.

In order to receive continuous illumination and avoid interference, or occultation, when the Earth is between the spacecraft and the Sun, SIM will be in a solar orbit, trailing the Earth by about 95 million kilometers after 5.5 years. The accuracy with which SIM will detect extremely small motions of stars is described by the designers as being able to "see the grass grow in your yard every second, from as far away as 10 kilometers, or more than 6 miles."

In the second decade of this century, NASA is planning to launch the next set of instruments to refine the search. The Terrestrial Planet Finder (TPF), which is still in the conceptual design phase, will challenge the scientific and engineering communities not only to find terrestrial planets, but also to measure the relative proportions of the chemical markers for life—carbon dioxide, water, ozone, and methane—in their atmospheres.

The Terrestrial Planet finder will use the technique of nulling interferometry to reduce the interfering glare of a planet's host star by a factor of more than 100,000, to reveal terrestrial-sized planets as far away as nearly 50 light years. The very sensitive infrared—as opposed to optical—interfer-



Jet Propulsion Laboratory/NASA

NASA plans to deploy the Terrestrial Planet Finder, shown here in an artist's illustration, in the second decade of this century. The TPF will use infrared interferometry to search for evidence of terrestrial planets as far away as nearly 50 light years from Earth. A series of telescopes will be deployed, each on its own free-flying spacecraft, to form a baseline between 70 and 200 meters.

ometer will be able to characterize the numbers, sizes, locations, and diversity of extrasolar planets.

TPF will also study the protoplanetary disks of material surrounding stars, in order to illuminate the process of planet formation, which is little understood, especially since massive Jupiter-type stars have been detected near to their host stars, in contrast to our Solar System. By studying the infrared emission from dust, ices of water and carbon dioxide, and gases in protoplanetary disks, information on the mass and temperature distribution across the disk should provide clues as to how solid and gaseous planets form.

To reach the sensitivity projected for the Terrestrial Planet Finder, a long baseline of telescopes is required, because the distance between the instruments determines the resolution of the measurements. Rather than construct larger and larger space structures to house such a series of separate instruments (such as the design for the Space Interferometry Mission), the Terrestrial Planet Finder is conceived as a set of four 3.5 meter diameter telescopes, each on its own spacecraft, flying in formation, creating a baseline between 70 and 200 meters. Other configurations involving four to six smaller telescopes are also under study, both by NASA and the European Space Agency.

Like SIM, the Terrestrial Planet Finder will be placed in an Earth-trailing orbit. The launch is projected for approximately the year 2010, and the mission is to be at least five years. It is projected to cost in the range of $2 billion. In the first year of its mission, TPF is to build on the results of the SIM mission and examine about 150 stars to characterize planets discovered by SIM, which will range in mass from that of Jupiter to that a few times Earth's mass. In subsequent years, it will carry out its program of identifying and characterizing the most promising new habitable planets.

Over the next decade, we will have available an avalanche of new data concerning the formation and character of other solar systems, and the possibilities that they might be inhabited. Today, theorists cannot explain what astronomers believe they have found in planetary systems so different from the one Kepler so eloquently described 400 years ago. Conventional theories rely on the primacy of gravitational interactions in protoplanetary disks, the formation of planetesimals, and the accretion of solid-body and gaseous planets. The astonishing finding that multiple Jupiter-like planets can apparently reside close to their stars, in highly elliptical orbits, has led to the theory that planets can form at great distances from stars, and then migrate inward. On the way, some surmise, they "bang" into each other, creating a certain level of chaos, which we observe in these unusual configurations today.

Other theories have been advanced in the past. In the 1970s, Swedish physicist Hannes Alfvén, who was awarded the Nobel Prize in 1970 for his work on the behavior of plasmas, proposed that the magnetic field of the Sun played a critical role in the formation of planets, and that electromagnetic fields dominated this process.

Plasma physicist Daniel Wells, professor emeritus at the University of Miami, has noted the similarity of the formation of force-free structures in a rotating plasma in the laboratory, to the geometric organization of planets in the Solar System, and has proposed that the process of formation is similar. (His work on this subject appeared in *21st Century* in 1988.[8])

As is the case in any fruitful field of scientific endeavor, the detection of extrasolar planets has posed more questions than it has answered. The combination of new data and unfettered, creative thinking, could soon shed light on the question of how planets and solar systems form, and whether or not there are habitable planets beyond the Earth.

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

Notes

1. Interview with Geoffrey Marcy, Feb. 3, 2000.
2. Alan Boss's book, *Looking for Earths: The Race to Find New Solar Systems*, published by John Wiley & Sons in 1998, is an excellent introduction to the history, technology, and science behind the search for extrasolar planets. Dr. Boss hopes to update this work, to include the most recent findings in this field.
3. Donald Goldsmith, *Worlds Unnumbered: The Search for Extrasolar Planets.* (Sausalito, Calif: University Science Books, 1997).
4. Interview with Paul Butler, Feb. 6, 2000.
5. Interview with Alan Boss, Feb. 2, 2000.
6. David Cherry, "Interview with Roger Angel: The New Telescope Mirrors: Rigid Honeycombs with Deep Curvature." *21st Century Science & Technology*, Winter 1997, p. 73.
7. "Searching for Life in Other Solar Systems," by Roger Angel and Neville J. Woolf. *Scientific American Presents, Magnificent Cosmos Edition*, Spring 1998, Vol. 9, No. 1, pp. 22-25.
8. "How the Solar System Was Formed," by Daniel R. Wells, *21st Century Science & Technology*, July-August 1998, pp. 18-28.

Russian Biologist Comments On What Distinguishes Living Systems

A leading researcher discusses the breaking frontiers of biophysics presented at the Second International A.G. Gurwitsch Conference, held in Moscow in September 1999.

EDITOR'S NOTE

Moscow University biologist Vladimir Voeikov is one of the foremost researchers in a school of scientific investigation almost unknown in the West. While Western biology has taken the path of reductionism, in which living processes are regarded essentially as molecular machines, *a completely different approach, based on the pioneering ideas of Vladimir Vernadsky, Alexander Gurwitsch, and Ervin Bauer, developed in the Soviet Union. The workers of this Soviet school recognized the distinction between living and non-living processes as* fundamental *and* irreducible. *According to Vernadsky, the existence and evolution of living processes on the Earth, and of human reason, as a further, axiomatically distinct process within the living domain, are no mere isolated or accidental phenomena, but constitute coherent expressions of a fundamental developmental characteristic of the Universe as a whole—a characteristic incompatible with the assumption of universal entropy.*

Professor Voeikov, a modern exponent of this line of thought, is Associate Professor and Vice Chairman of the Department of Bio-organic Chemistry, Faculty of Biology, at M.V. Lomonosov Moscow State University in Moscow. Voeikov was one of the organizers of the Second International A.G. Gurwitsch Conference, held at the University in September 1999, which he discusses here. He was interviewed in October 1999, by Jonathan Tennenbaum, who heads the Fusion Energy Foundation in Europe.

Photos courtesy of Vladimir Voeikov

Prof. Voeikov in his Moscow laboratory, with a device for single photon counting.

Question: Where do we stand today concerning the most important questions raised by Gurwitsch and his school?

First, I think that the most important claim made by Gurwitsch is, that the weak light emissions—not only the mitogenetic radiation—have an important biological function. There are now many papers in the literature which show that this is the case. Gurwitsch's idea of ultraweak light emission from living cells is that this emission is not just a by-product of their activity, having nothing essential to do with that activity and having no effect on it. The ultraweak radiation is not like the noise produced by the workings of a machine, but represents an important biological function. It seems to me that this has been substantiated.

Second, the idea of the biological field. You have to take the essence of his idea. He didn't specify what kind of field he was thinking about, whether for example it is electromagnetic, or chemical, or any other. But the idea was, that it was dynamic and heterogeneous in the holistic space of the living system. Because of this field, there are not only local interactions between neighboring elements, but there is a general principle which unites the organism as a totality. So, it seems to me now, that without this idea of a totality, many many things cannot be explained. A lot of work shows this.

Whether people are studying electromagnetic interactions, or mechanical interactions—such as mechanical forces in embryonic development—you may still speak about chemical and mechanical fields, because these fields are oscillatory and have gradients. They are changing in time and space, and a change in one place in the gradient will immediately be reflected in some distant place.

A spider's web just made by the spider, may serve as a good analogy for such a type of field. As soon as a mosquito gets caught on the web somewhere, its efforts to get out change the rhythmic patterns of the web itself, at all the points within its boundaries—remember that the web is usually under tension. It seems to me that much depends on what methods investigators use to study these fields. If you are studying phonon [sound] fields, you apply a certain specific method, and if you are studying electromagnetic fields, you apply quite different approaches.

Question: But isn't Gurwitsch's sense that in studying all of these phenomena, all of these physical manifestations, we are ultimately measuring one and the same entity, a single total field?

Yes, you measure different manifestations of the same field. This field has as many different manifestations, as the number of fields in physics that we know of. I am not talking about gravitation, but nevertheless, one may think of such a strange idea.

Question: So it's a kind of physical phase space or physical manifold?

Yes. To my mind Gurwitsch was wise enough not to specify the nature of the field, because it depends on what you are looking at, and how you are studying it. All of these specific fields are, of course, interconnected, and coupled to each other. Electromagnetic oscillations may build up to sonic oscillations, and mechanical stress is converted into chemical gradients—and so, you see, there are very many potentialities. It is very difficult to identify all of them. So, now we are at the stage where the basic ideas of Gurwitsch, which were put forward more than 70 years ago, have been substantiated. Of course they are not acknowledged by the whole scientific community, but that is only a question of time.

Gurwitsch wrote that the future development of science will show the relationship between the picture of living systems revealed by mitogenetic radiation, and the picture presented by classical genetics and biochemistry. He believed that the wall separating them would someday be broken down. And we are presently at the point of bifurcation when this wall is breaking down.

Question: Can you give some specific examples of this?

My examples come from studies of complex systems, and from some very new physics. It seems to me that, unfortunately, most molecular biologists and professionals in biological chemistry, either forgot or did not study physics. Or, the physics they studied at the universities was not enough to understand all these things. Physics is developing just now very quickly, in new directions. We did not know the word fractal 15 to 20 years ago, and now we use it to talk about the nature of blood, the nervous system, the cytoplasm, and so on. And what is a fractal but a new manifestation of some kind of field? You can call this a fractal field, and there are a lot of examples in biology of this fractal nature, and changes in fractal dimensions during the biological process.

Several of the participants at the Second International Gurwitsch Conference, held in Moscow in September 1999. Scientists attended from Germany, Russia, Israel, Georgia, Kazhakstan, Switzerland, the Netherlands, Ukraine, Slovenia, China, and India.

Question: But I think Gurwitsch had in particular the idea, that investigations of mitogenetic radiation, revealed some phenomena which are not explicable from the standpoint of what was then known about biology. For example, something very simple, like the surprisingly strong emission of living tissue in the ultraviolet range, which is many orders of magnitude larger than would be expected on the basis of simple thermodynamics. Where do all these high-energy photons come from?

Yes, exactly. You see, he understood that the physics of his day was not enough to explain what's going on, even on the physical level. A lot of explanations about photon intensity did not work at all.

Question: Another specific area where Gurwitsch's results differed radically from conventional biology, is cancer. For example, Gurwitsch's notion of the "cancer extinguisher."

Concerning cancer, the mitogenetic work has virtually no connections with classical oncology. In fact, in oncology we have not progressed very far from what was done in Gurwitsch's time, because very few people understood or knew about the phenomenon of the "cancer extinguisher." If you talk to people who are working in oncology you will find no one who knows this word or these investigations [by Gurwitsch]. It is not because this work was destroyed, or that he turned out to be wrong, but simply that nobody has worked in his direction for decades.

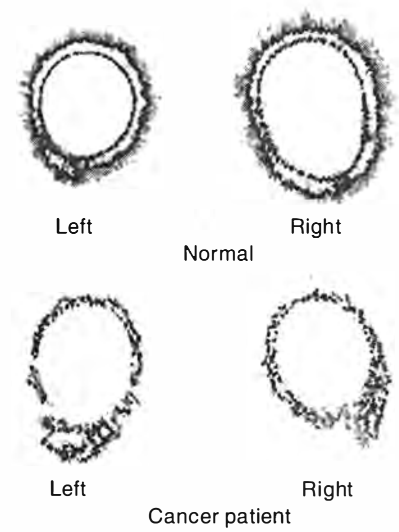
But now there are more data showing that something really changes in the organism as a whole, when malignancy occurs. Most wise oncologists understand that they are not dealing with some mere local deviation or change in the body. There is a change in the whole organism when a tumor appears, which is like a phase transition. In fact, Gurwitsch, in talking about the cancer extinguisher, probably didn't use that expression, but he meant the same thing: that something changes in the organism as a whole.

There are data which show that blood from those patients with malignancy, changes drastically, *as compared to* people without disease. These are not very deep data, but there are many indications of this type. One of these was in the paper of Valeri Orel at our conference. Working at the Institute of Oncology in Kiev, he studied the kinetic parameters of mechano-luminescence of blood taken from animals with very different malignancies, and also from patients with various different pathologies. His long-term studies show that there is something in common in the blood of subjects with malignancies.

Question: With respect to the characteristics of their photon emission?

The oscillatory pattern of photon emission, induced by mechanical pressure upon blood specimens of animals and humans with cancer, are characteristic only for them, and the pattern differs from the normal.

Another direction of research is using the Kirlian effect, which was reported in a paper by Konstantin Korotkov at the Gurwitsch conference. Last week I met him, and he said there is a group in Tbilisi, Georgia, that is studying the dynamic process of the Kirlian effect, using video cameras and processing the data by computer—and they have fantastic results. Using this approach, they diagnose cancer in people with 95 percent reliability. There was a large screening of several hundred people, in a hospital in Tbilisi. The persons conducting these investigations were not told if the person tested had cancer or not, so it was a blind test. They gave their results to the doctors, who didn't believe them: In 95 percent of the cases, they were correct in their diagnosis.



THE KIRLIAN EFFECT

Patients with cancer have different emission patterns detectable at their finger tips, a phenomenon that in initial research in Georgia was used to diagnose cancer with a 95 percent accuracy rate, as reported at the Gurwitsch conference. First fingers of both hands are compared here.

Question: Is this published?

Yes, their report has just appeared, but only in a local Georgian technical journal. These data are very fresh, only two or three months old. Now, we cannot explain very well what Kirlian emission is, but to my mind, it involves a kind of amplification, like field emission. It is not just the corona discharge. It is generated with a high frequency potential applied to a living system, which is not in equilibrium. That is different from applying the same discharge to a non-living object. Here you have something additional, which is some kind of nonequilibrium.

Now, when we are talking about Gurwitsch's extinguisher, it decreases this level of equilibricity. The person having a malignant tumor has a different level of nonequilibrium. This is probably why it can be discovered using such approaches.

In fact, Gurwitsch discovered it using his own approach of mitogenetic radiation. Blood from cancer patients didn't emit mitogenetic radiation. Gurwitsch showed why it does not emit, because the extinguisher is a strong antioxidant. It does not allow the radicals to recombine and to build up an energy potential. The sick person has a different energy potential than a healthy person does.

So, when we look at this problem from very different angles, and unrelated approaches, we come to the same idea and discovery of Gurwitsch.

As with everything that concerns Gurwitsch, the problem is: He said his ideas would require a new era, but most researchers don't want this new era, for purely psychological reasons. I can understand that. It is very inconvenient for most of them. Max Planck once described how this happens in science.

Question: Gurwitsch spent much time studying the spectroscopy of mitogenetic radiation, and also the phenomenon he referred to as "degradative radiation," which is emitted when living tissue dies, or is subjected to various kinds of trauma. What has happened to these directions of research?

They have not been developed until now because, first, Gurwitsch was working in the ultraviolet region, and most people who are studying ultraweak light emission now are working with much longer wavelengths. Nobody knows what the spectral distribution is there. Second, Gurwitsch used biological detectors, whereas today we are using photomultiplier detectors. Biological detectors are at least two orders of magnitude more sensitive than photomultiplier detectors. This difference may explain why we cannot see the same things he saw, using yeast cultures as biological detectors.

Today, it is more obvious, that he was correct about the coherence of this radiation. A photomultiplier detector working in the mode of single photon counting, is not a phase detector. It does not matter if the photons detected are packaged coherently or not. A biological detector is a phase detector, and it is sensitive in that way. That is possibly why using yeast detectors it was possible to resolve the mitogenetic spectra of biological emitters, and even from chemical reactions, into very narrow, down to 1 nm width, wavelength bands. Noncoherent emission in other wavelengths was simply not efficient in triggering the mitogenetic response. Thus, those who tried to use the photomultiplier to either prove or disprove Gurwitsch, made a major mistake.

Question: That is a very important point.

Among the most interesting of Gurwitsch's experiments, was when he placed a rotating disk with a sector-shaped [pie-wedge] opening between two yeast cultures, and set the disk to rotate at various frequencies. Then the effect of one yeast culture upon the other, via photon emission, is much stronger at certain rotation frequencies. There is an intermittence in the signal exchange. From the point of view of simple physics, the intensity of the interaction should go down, because most of the time these two objects are cut off from each other. They see each other only during tiny intervals. So intensity becomes lower, but the efficiency becomes higher.

That may be interpreted as a kind of time coherence. The objects see each other at specified times. The biological information doesn't depend so much on intensity, as it does on frequency and phase relations. For me it is very simple. I can shout on the telephone, or whisper on the phone within the range of your hearing sensitivity, and you get the same quantity of information from me. My information does not depend on how loud I speak, within a certain range. On the other hand, I can increase the intensity so much that you get no information at all. This is an idea that explains a lot of things.

Question: What about the degradative radiation and its implications?

The phenomenon of "delayed luminescence," which Fritz Popp [one of the leading researchers in the field, who founded the International Institute of Biophysics] studies all the time, with its hyperbolic decay and so on, is, to my mind , degradative radiation. He induces this radiation by a light flash, investigating the subsequent re-radiation—"delayed luminescence"—from the sample. The intensity of the light flash has nothing to do with the intensity of the delayed luminescence. When he illuminates a leaf, or something like this, the flash has so many photons, that they cannot be counted. It is just an impulse, which affects the nonequilibrium constellations in the system. In fact, he can apply not only light, but also an electromagnetic pulse, or some other kind of disturbance, and he sees photon emission which decays by this hyperbolic law. That is degradative radiation.

From archives of L. Beloussov

Alexander Gavrilovich Gurwitsch (1874-1954)

Question: Although, as I understood the degradative radiation, Gurwitsch associated this with some kind of damage. . . .

From the biological point of view, any irritation or signal can be like damage. Take the classical physiology of isolated nerves. Applying a force can trigger a nerve impulse, an electrical impulse. As soon as you have a propagation of the nerve impulse, you have a signal. But if you apply this same force to the nerve when it is in the refractory phase, it is pure damage. We should distinguish between damage and irritation. The same signal which is informational under one specific condition, is damaging under another. Degradative radiation is just a reflection of a system that was in a non-equilibrium stationary state, that was pushed away from that stationary state, and now it is reacting. The reaction is a release of energy. It is potential energy which becomes active energy, and some of this is released from the system and we observe this as degradative radiation. The name is a bit unfortunate.

Question: Did Gurwitsch invent it because he was studying systems that were dying or injured?

Well, he induced degradative radiation with many different kinds of factors, such as centrifugation and fast cooling. On the other hand, he could look at the liver of a mouse *in situ,* while the mouse was alive, and the liver was connected to its nerves and blood supply. He injected glucose into the blood of the mouse, and there was a release of degradative radiation from the liver. So, each time we feed ourselves, there is a release of degradative radiation. It is just a manifestation of work being done by a system.

Question: One aspect of Gurwitsch's work, which you yourself have been following up, is connected with so-called branching chain reactions.

All of my work is based on this idea of Gurwitsch, and I have always acknowledged, that he was the first who talked about chain reactions in the biosphere. These reactions may be described by the equations for chain reactions with delayed branching. For example, the process of microbes multiplying in a culture, can be described by the same equations as any runaway chain reaction. But, Gurwitsch was talking about chain reactions in a very specific sense, which involves the participation of free radicals. In the 1930s, people thought these reactions could exist, but nobody could measure them. Electron paramagnetic resonance, which was introduced much later, was needed in order to demonstrate that such chemical species really occur. But Gurwitsch was really talking about these free radicals—their existence and their participation in these chain reactions. I have written about this in the biophotonics book.[1]

Now we have very solid data that these reactions really take place in aqueous solutions of the most simple kinds of biological molecules, like sugars and amino acids. I describe this in my paper in the biophotonics book. We see these reactions taking place, and we have proofs of the presence of branched chain reactions, or runaway chain reactions in this system. Since this takes place in such a model system, I have no doubt that it takes place in the organism also. So, to my mind, Gurwitsch was not only correct, but he laid the foundations for my investigations.

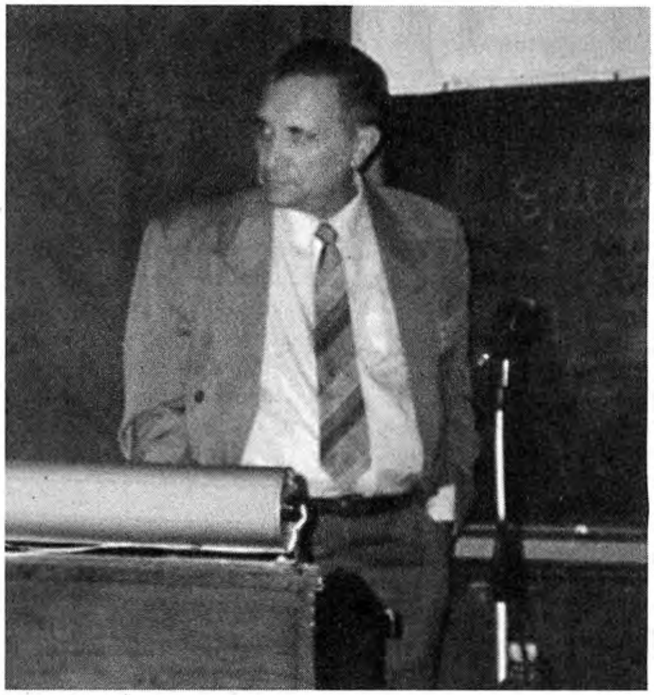
Question: Could you tell us about the conference which you just held in Moscow [the second International A.G. Gurwitsch Conference]?

It was organized by the International Institute of Biophysics, and Fritz Popp, its founder, was there as a leader in the field, with the active participation of the Moscow University Faculty of Biology, which had been mandated by the Rector of Moscow University to contribute to the holding of this conference.

Question: I spoke to Fritz Popp today, and he said he was very impressed by the interest and the commitment of Moscow University to this kind of research. What were the most important developments presented at the conference?

I would say the most important development to report, was actually not closely connected to biophotonics or Gurwitsch's field. It was a paper of Simon Shnoll. It seems to me it may be very important, maybe the most important paper of the 20th century in this field. It was published in 1999, in *Uspekhi Fisicheskikh Nauk,* one of our most respected journals in physics. There were a lot of discussions with physicists here in Russia, before the paper could be published.

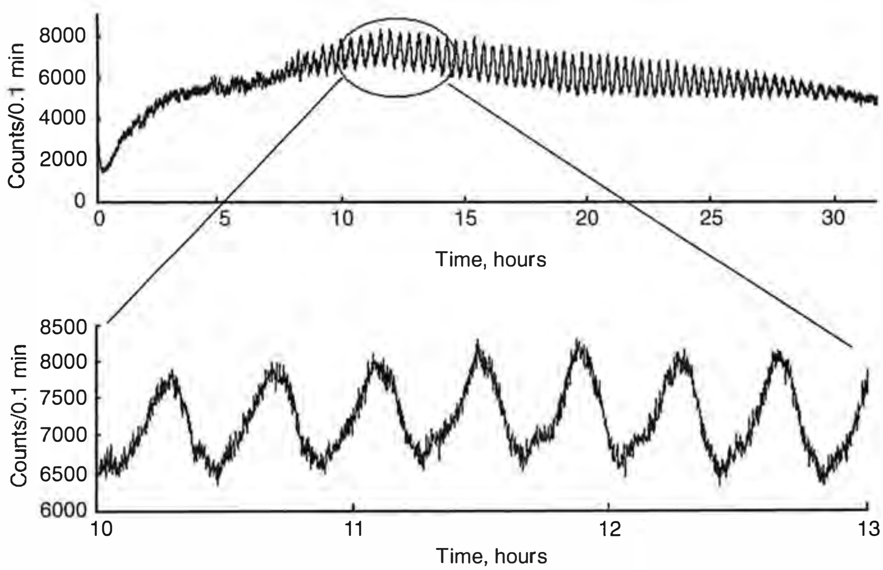
Shnoll's work shows that time is heterogeneous. It is not a Newtonian time. Each moment in time is different from another, and this can be seen in any physical processes which you study. His results show that there is information, cosmic information, which is affecting all the processes on Earth. That is most important. We are not just a system open to non-structured energy and matter from outside. We are an open system relative to structured information.



Prof. J. Injushin, author of the bioplasma theory and the inventor of the low-level laser irradiation technique for biomedical applications.

Question: To the universe?

Yes, to the information of the universe, because it has order. And this order is very complex, but nevertheless we receive it at each moment of our lives. So it seems to me that it is most important, because without it no biological fields would exist. Some initial order comes from the outside. Nothing comes from nothing. Something was always ordered. So Shnoll shows that there exists such a thing. We cannot now explain what it is, or where it comes from, but



PHOTON EMISSION RECORD FROM GLUCOSE AND GLYCIN REACTION

A record of photon emission from the reaction system where the Beloussov-Zhabotinsky-like reaction between glucose and glycin is taking place. Regular oscillations are gradually emerging in the reaction without any external interference, and they continue for about one day. This type of reaction was discovered in the laboratory of V. Voeikov.

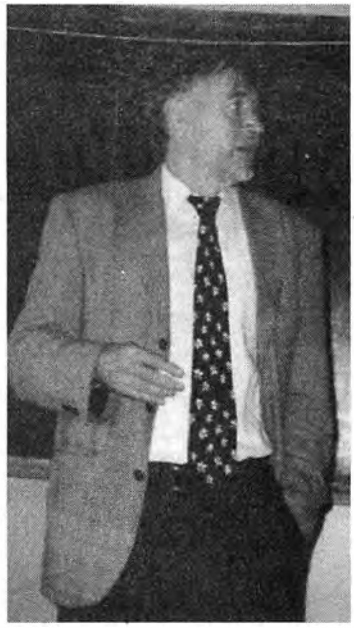
we know it is not a local phenomenon, but a global one.

Question: As I understand, Shnoll's work demonstrates similar sorts of temporal variations occurring in an extremely wide variety of physical measurements, taken simultaneously at different locations on the Earth.

Yes exactly. Just recently, [Lev] Beloussov [a grandson of Alexander Gurwitsch] and I tested this with photomultiplier measurements. Beloussov was in Fritz's laboratory [in Germany], and I was here in Moscow. We switched on our photomultipliers and analyzed the dark signal. We gave this data to Shnoll, and he got what he expected to get.

Question: What about the papers presented at the conference on biophysics proper?

A very important paper was from Popp, returning to the subject of oncology, and talking about very special properties of carcinogenic molecules. In fact, using quite different approaches, he again proved what was shown in Gurwitsch's laboratory by N.N. Kannegisser in the 1930s: that carcinogenic substances are distinguished from chemically very similar, but non-carcinogenic substances, by the characteristics of their own light emission.



Prof. Fritz-Albert Popp, founder of the International Institute of Biophysics.

Question: Are you talking about Popp's work on benzpyrene?

Yes. These results have shown that carcinogenic substances were very stable emitters of mitogenetic radiation, resulting from slow oxidation. Because of this property, they begin to irritate or stimulate cell division continuously, unlike the stimulation which is organized by the organism itself. They constantly tell the cells that they should divide. And because of this constant signal, some cells break down, and some of them of course die. The rest begin to behave in such a way, and become deaf to the signals from the organism, forbidding them from dividing.

Fritz Popp did his early work before he knew anything at all about Gurwitsch's work in this area. This is a very clean experiment which shows that Gurwitsch was right. Popp did not start out to prove or disprove Gurwitsch, but he came to the same conclusions as Gurwitsch in a very different way.

Another very important paper was presented by V.V. Maksimenko, a physicist. The paper is about light localization, or, I would better describe it as light storage in reflecting media. That is a most important paper not only for biology, but also for physics. He showed that if you have a medium that does not convert light into heat, but is a completely reflective medium, then light can be stored in this medium. And nobody knows how much light energy is stored there, because the photons which get into such media, change their velocity, down to zero. That means that they have the same frequency as they had before, but no wavelength. How much light can be stored in this way in such a medium, nobody knows.

Question: How does this function?

If you have a reflective medium with a specific fractal parameter, it has such a property. When we are talking about biological media, they are also highly reflective. You have a great number of boundaries there. Some boundaries we can see; these are membranes. But there are a lot of boundaries which cannot be seen because of their dimensions. You take a protein solution in water. Each protein molecule is hydrated, and just from ordinary physical chemistry, hydration water is different from bulk water. So that means there are two phases of water, hydration water and bulk water.

Now, there is a boundary between these two phases, and this boundary should reflect light. At this boundary there is a change in the dielectric constant between the two phases, and there is a change in the light speed as it passes the boundary. The light changes its wavelength, at the same frequency, and, under certain conditions, it can travel very slowly, and it can even stop.

What does it mean if it can stop? It means that it is localized, and stored. And you can localize a lot of light in this way—how much nobody knows, but that is a great energy, and you can extract some of this if you change the properties of the system.

Now, returning back to degradative radiation and coherent fields, Maksimenko's work gives some plausible answers to some of the most difficult questions which arise from Gurwitsch's experiments.

Question: Is this theoretical work, or is he also experimenting?

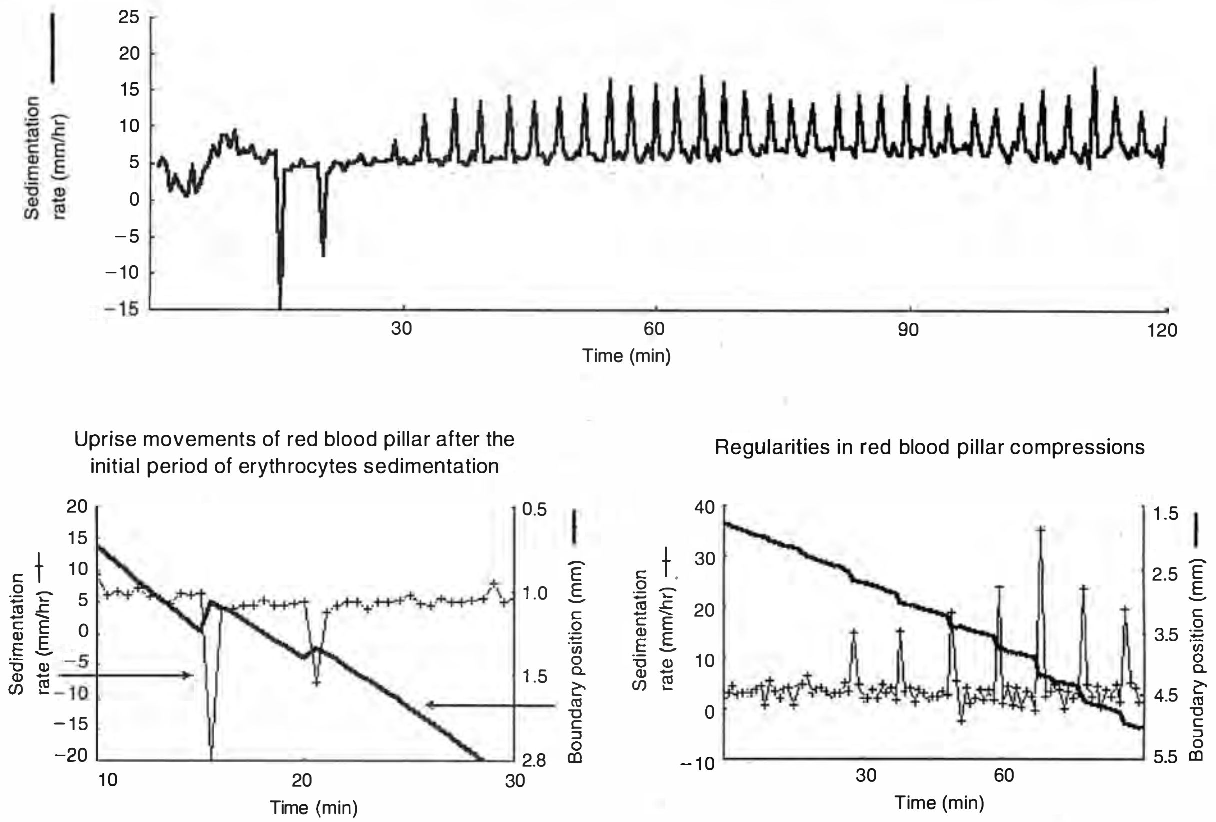
He is a theoretician, but he works with experimenters, and works with people who are not in biology, but in solid state physics, with investigations on the anomalous reflection of light from certain kinds of dust. There is also a group in Holland, which has published a paper in *Nature* on light localization, so this idea is growing. But concerning the application to biology, we initiated Maksimenko's thinking in this direction, because he is a pure physicist, and he did not imagine that his ideas could apply to biology. Now we see that they can.

Popp was thinking, if you remember, about the concept of "photon sucking," and exactly that is what is going on. If you have some cavity, with some photons stored in this cavity, and if you put a substance with these properties in this cavity, then light can go there and be stored there. So it would be photon sucking. It's like a black hole.

Question: It adjusts the phase of light in such a way that it is localized.

Yes. That is probably what photon sucking is, and that is not the only explanation. There are other ways to suck photons, but this one works.

Now, another very important work is by A.V. Budagovsky,



BEHAVIOR OF HUMAN BLOOD DURING SEDIMENTATION

Detailed behavior of human blood during sedimentation of red blood cells in a standard ESR-test. The record is obtained using a special optoelectronic device designed by V. Voeikov and colleagues.

who demonstrated that coherent radiation has a very specific effect upon living tissue. He also demonstrated that the secondary radiation discovered by Russian radiobiologist Alexander Kuzin is coherent. Unfortunately, Kuzin died in July at the age of 94, just three months after he had published his last book.

Question: What is this book?

This book is about hormesis and secondary radiation. Kuzin was one of the proponents of radiation hormesis. As a matter of fact, a paper on this subject was published in the same issue of *21st Century* magazine that my article was.[2] Kuzin had a great amount of data which prove the beneficial and necessary role of low-level radiation on living things. For quite a few years, he was trying to explain the mechanism of radiation hormesis, and he came to the explanation that radiation hormesis is realized through mitogenetic radiation.

A Georgian biophysicist, A.A. Kozlov, presented the paper at the conference, containing a direct proof that background radioactivity is necessary for cell division.

Question: Do you mean what is sometimes called ionizing radiation?

When we are talking about ionizing radiation, let's not forget that we are usually talking about high doses. As soon as you go to lower doses, the probability of ionization goes down, and the probability of strong excitation goes up.

Question: Even though the quantum energy is high?

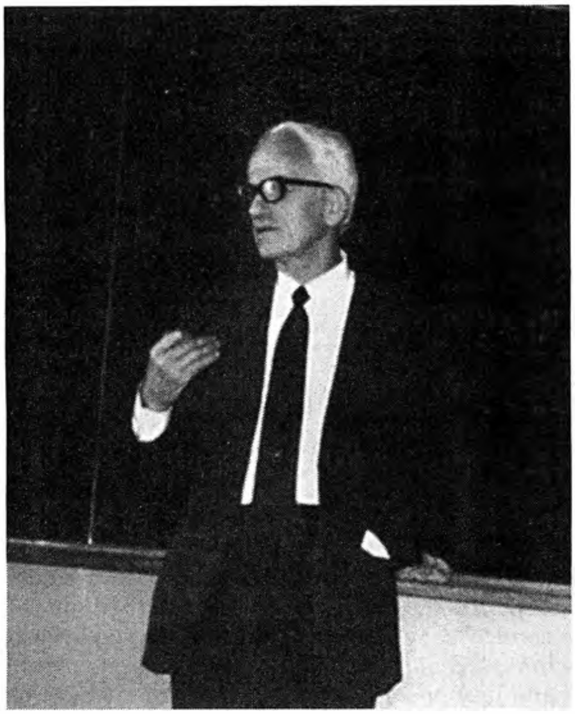
Yes. Now, with regards to this quantum energy, it is best understood for beta particles, and can be explained for gamma particles from this point of view. As soon as you have a beta particle in water, or liquid, and as soon as the energy of the beta particle exceeds 263 keV, it generates Cerenkov radiation. It is very well known. What is Cerenkov radiation? It is ultraviolet radiation. The energy of Cerenkov radiation quanta in aqueous solutions is about 4 to 5 eV. Now, if a beta particle energy exceeds this threshold of several hundred eV, then as soon as it passes through water, it generates ultraviolet light.

Question: So such events would lead to a kind of mitogenetic effect?

Exactly. Because the energy of the Cerenkov radiation is about the same: 4 to 5eV.

Now when we are talking about gamma radiation, gamma quanta are absorbed by nuclei. When they are absorbed by nuclei, a beta particle, or other secondary radiation is dissipated, generating several electron-volt quanta. Those several electron-volt quanta of electromagnetic energy are exactly what is called mitogenetic radiation. So Kuzin has shown, that as soon as you irradiate living tissue—a leaf, or seed—with low-level gamma rays, these generate secondary radiation that stimulates growth and development, and so forth.

Kozlov examined the length of the mitotic cycles in a paramecium culture exposed to normal background radiation. Then he shielded them with lead, to decrease the background radiation, and the mitotic cycle length increased. He increased background radiation, and the mitotic cycle length decreased. He showed the phenomenon of saturation: For division we need some internal events, such as DNA replication. You cannot stimulate a cell that has not completed the events needed for mitosis. There is some internal clock in the cell. It can wait for a long time, for some external signal.



Prof. Simon Shnoll, giving a presentation on the cosmophysical factor that affects the behavior of physical processes.

Kozlov found, that not only for paramecia, but for very many organisms, that 10 times the background radiation is saturating. So if you take 20 times background or 40 times, you get nothing more, besides injury. From this and some other approaches, he calculated that each cell has to receive 5eV to initiate mitosis.

Now about this notion of energy here. Energy may be measured in joules or electron volts, and these are quite different things. You can have a glass of water heated to 100 degrees, which has a large energy difference with the environment at 20 degrees. It is a lot of energy. But the energy potential is *zero point zero, zero, etc.* [0.00. . .] electron volts—practically nothing, but you have a lot of energy. If you take several photons of 5eV, and if you integrate this energy, you get almost nothing. Yet it has an effect: It is *information energy.*

Question: Or you may call it *geometric energy.*

Yes. So that is the difference. It is not a problem how to get these high-energy photons into the organism. There are free radical reactions going on constantly in the organism, and free radical recombinations always give energies in the range of electron volts. These radical reactions must be very rare from the standpoint of classical bioenergetics and thermodynamics, and yet, without these radical reactions a living system cannot work.

I can make a superficial comparison with a car engine. Why is the car running? Because a lot of energy is released during the combustion of the gas. OK, but you need spark plugs to get it to run. The energy released by the spark plugs is not comparable to the energy which is released from the burning of the gas. But there is a sizable energy potential at the spark plugs: There are several kilo-electron volts there. You cannot run the car using only the spark plugs.

I compare this to the relationship of mitogenetic radiation of free radical reactions, to the general bioenergy of the organism. The organism needs sparkplugs. That is the function of mitogenetic radiation. That is the function of these extra high-energy quanta of gamma rays. You need only a few of these gamma rays in order to multiply them into many ultraviolet quanta, and these ultraviolet quanta are multiplied by several orders of magnitude into biochemical reactions, with much lower potential, but an incomparably larger volume of energy released.

Question: Are there other aspects you wanted to mention regarding the results of the conference?

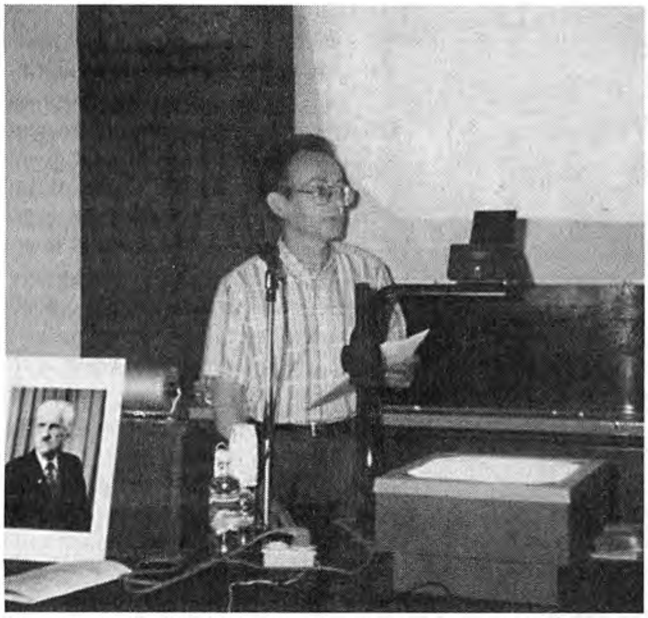
I would like to say some things about the study of blood. Blood is not a soup of various components. Blood is an organ. This is the word I now use. We see this, especially, using our method of studying the erythrocyte sedimentation rate dynamics. This is a tool to study the way blood reacts to environmental conditions, during the time it is put into a pipette. It is the reaction of a stressed living thing that wants to survive. It uses for its survival all of its energy resources. The graphs of sedimentation rate show a strong oscillation in the rate over a period of many hours. I can compare it to descending steps. It is as if you have a ladder, you may stand on a step for some time, and then if you move, you immediately fall down a step.

There are a lot of new data we generated with this approach. The presence of oscillations shows that this method, which was used for almost 100 years, was not understood completely until now. People were trying to explain erythrocyte sedimentation in terms of the standard mechanical laws for sedimentation of particles in a viscous medium. What we are observing here has nothing to do with this sort of physics. It is completely a biological process. The blood is not sedimenting. A three-dimensional network of red blood cells is formed as soon as blood is taken into a pipette for ESR measurements, and this network is compressing. Blood resists this compression, and it uses its energy against compression. It can even retract.

But why does the compression still go on? Because the sedimentation reflects oxygen consumption by white blood cells from red blood cells. That is the oxygen-delivery process in blood. So it has nothing to do with viscous medium physics.

Question: It's an organized biological process.

Yes. We see, for example, that it doesn't depend on viscosity. Viscosity may be high, and sedimentation may be very



Prof. Vladimir Voeikov, opening the conference session devoted to the memory of the late Prof. Alexander Kuzin, renowned Russian radiobiologist and proponent of the hormesis theory (shown in photo on table).

high. Viscosity may be very low and sedimentation also very low. Just completely opposite to what is expected from the standard laws of a viscous medium. I don't mean that these law are not correct, but only that they hold for nonliving systems, and their manifestation in living systems is seriously influenced by the living system's own activity.

Question: In closing, I would like to go back to one of the most basic questions in the whole field, which is to identify the source of the biophoton emission.

You see, the question is like asking: What is the source of the light from a laser? The laser has to be pumped. Is the source of light the pumping system for the laser? For me it is just the same for biophoton emission. The biological system is the working body of the laser. It has to be pumped with an energy of rather high potential. The pumping comes from radical reactions, and a little from radioactivity. Now, the source of photons is the microlasers, which are these coherent fields which exist all over the body.

The best analogy is a laser. There is a pumping system, and a system which can be organized and excited. After excitation, there must be some kind of irritation which releases this light. If irritations are small, then we have what we call spontaneous light emission, which is usually very low. If it is systemic, then we have what Gurwitsch called degradative radiation, and the particular light emitters are these nonequilibrium systems, which are in a liquid state in the organism. Just very recently, we found that ordinary water is a rather strong light emitter.

Question: In what circumstances?

You take ordinary water and put it into an efficient photon detector, and you can find emission up to 20 times the background level.

Question: My impression was, that the attempt to compare the biophoton emission with some kind of digital signal is very primitive.

Well, it is primitive, but it also makes some sense. That is another long story, because it may be digital or it may be analog. In fact, it is both.

Question: What I am referring to in the domain of what we call communication—and a similar problem plagues molecular biology—namely, that you miss everything important when you just look at the mechanics of the form of communication, and forget the living processes which are the emitters and receivers. Signals have no meaning by themselves.

Exactly. You see, I can have before me a book with Chinese characters, and probably there is a lot of information there, but it is only strange pictures to me. It means nothing; no information.

Question: Well, we didn't get to all the questions I wanted to ask, but the time is limited. I want to thank you very much. Have you been able to say most of what you had in mind?

For me to say most of what I had in mind, I would need one week. . . .

Notes

1. *Biophotonics: Non-equilibrium and Coherent Systems in Biology, Biophysics, Biotechnology* (Moscow: Biolnform, 1995). This is the English-language proceedings of the first International A.G. Gurwitsch Conference, held Sept. 28-Oct. 2, 1994, in Moscow.
2. Voeikov's article, "The Scientific Basis of the New Biological Paradigm" appeared in the Summer 1999 issue of *21st Century*, (p. 18), as did "Radiation Protection Policy: A Primer," by Dr. Theodore Rockwell, p. 13.

Collateral Reading from *21st Century Science & Technology*

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- Introduction: "Alexander Gurwitsch: Father of Biophysics" by Colin Lowry, p. 34
- "Alexander Gurwitsch and the Concept of the Biological Field, Part 1," by Michael Lipkind, p. 36
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Fall 1998 issue:
GURWITSCH'S NON-REDUCTIONIST BIOLOGY, Part 2:
- "Alexander Gurwitsch and the Concept of the Biological Field, Part 2," by Michael Lipkind
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Winter 1998/1999
- "A Dialogue on the Importance of Keeping People in a Healthy, Unbalanced State," by Jonathan Tennenbaum, p. 28
- "On the Fate of Gurwitsch's Work," p. 30
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- "The Scientific Basis of the New Biological Paradigm," by Vladimir Voeikov, Ph.D., p. 18
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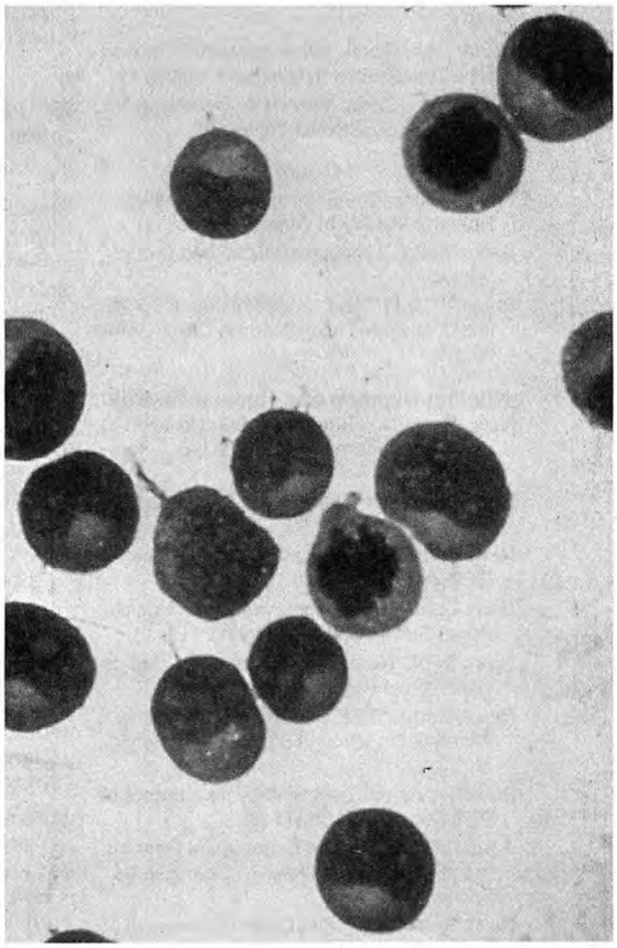
Promising Cancer Vaccines Move From Lab to Clinic

by Colin Lowry

By the time malignant cells have proliferated to the point that a person is diagnosed as having cancer, these cells have already evaded the body's own immune system defenses. Cancerous and damaged cells normally are destroyed by the immune system, but malignant cells that succeed in establishing tumors, have done so by fooling or crippling an immune response that normally would be directed against them.

What if the immune system could be "retrained" to recognize and attack the tumor? This is the idea behind cancer vaccines. Unlike traditional vaccines, the cancer vaccine is a therapy, delivered after the person already has the disease, not before. Training the immune system to eradicate malignant cells offers a nontoxic way to treat cancer, and even to eliminate recurring tumors.

For the first time, a cancer vaccine therapy, which is specific for a common lymphoma, has been approved by the National Institutes of Health to start large-scale, phase-three clinical trials with patients. The cancer vaccine against follicular lymphoma, was made from a unique receptor-protein found on the surface of the malignant cells, and it has proven itself effective in keeping 90 percent of vaccinated patients in complete remission for four years after treatment in the phase-two clinical trial.



Tom Folks/NAIAD

Normal T-cells. The production and activation of T-cells that can destroy malignant cells is the goal of cancer vaccines.

The phase-two trial, led by Drs. Maurizio Bendandi and Larry Kwak at the National Cancer Institute, was the culmination of years of research in immunology, and of earlier clinical studies.

Special Design Problems

There are three central problems that the design of a cancer vaccine must overcome, in order to be effective. First, a specific target-antigen that is unique to the cancer cell must be used, such as a protein on the cell surface, so that the immune system will target only cancer cells. Second, the vaccine must break the tolerance of the immune system to the cancer, by stimulating the production of its T-cells and other cells that will attack the tumor. Third, of the many different ways to present an antigen to the immune system, researchers must find those ways, possibly only one or two, that may work with a certain antigen.

In the clinical trial by Bendandi and Kwak, the antigen for the vaccine was the specific type of B-cell receptor known as immunoglobulin (Ig). Ig is a surface protein that has a variable region which is unique for each type of B-cell. In this case, B-cell lymphomas were isolated from each patient, and then the Ig protein from each patient was used as the target antigen.

However, Ig alone does not induce a particularly strong immune response. Therefore, in order to overcome this problem, the protein was fused with a highly antigenic carrier-protein, called KLH. The KLH acts as a flag, which is easily seen by responding immune cells, and which guarantees that the target antigen Ig will also be seen. B-cell lymphoma presents yet another challenge: The B-cell is itself an immune cell which normally produces antibodies, making it a special problem to try to direct other immune cells to see the B-cell as an "enemy" that should be attacked.

The immune system naturally encounters foreign antigens in two ways:

(1) antigens that are flowing freely in the blood or lymph, and (2) antigens that are on the surface of cells, often bound to a receptor. In the case of antigens in the lymph or blood, T-cells of the CD4 type bind the antigen, and then present it to B-cells, activating the production of specific antibodies that can then bind to that antigen. The activated T-cell also can secrete chemicals called cytokines, which can signal other immune cells and T-cells to divide and proliferate.

Killing the Tumor Cells

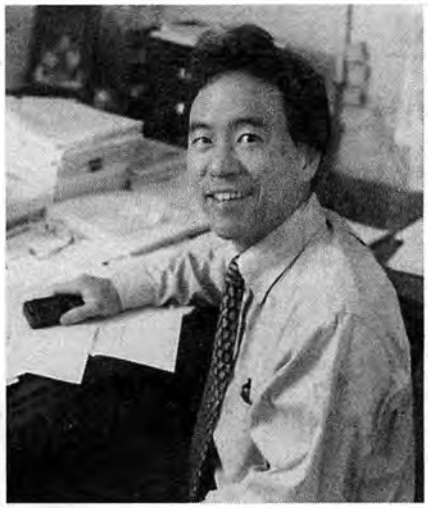
Antibodies alone do not kill pathogens; they merely tag them for destruction by other immune cells, such as neutrophils or macrophages, which engulf antibody-coated targets. This antibody-directed response is known as humoral immunity, but it is not designed to eliminate infected or malignant cells.

Usually, infected or malignant cells are recognized by antigens presented on a class of immune receptor called MHC I, on the cell membrane. MHC I receptors contain protein fragments that were generated inside the cell. A malignant or infected cell will present different proteins on the MHC I receptor than does a neighboring healthy cell. T-cells of the CD8 type can bind to MHC I, and then kill an unhealthy cell by lysing it (chemically perforating the membrane, and exploding the cell). The CD8 T-cell is also called a cytolytic T-cell, and it is this class of cell which must be activated for a cancer vaccine to be effective.

In the cancer vaccine formulation of Bendandi and Kwak, another element was added to activate the immune system in the form of a cytokine. From previous clinical trials, it was determined that the cytokine granulocyte-monocyte colony-stimulating factor (GM-CSF) was very effective in stimulating a CD8 T-cell response when combined with vaccine antigens.

Very Promising Results

In the phase-two trial, 20 patients with follicular lymphoma (FL), all in their first remission after chemotherapy, were vaccinated with the Ig-KLH plus GM-CSF formulation developed from their own tumor cells. The most common problem with FL is that it recurs very frequently, because the standard chemotherapy treatment cannot specifically eliminate all of the malignant cells. The goal was to see if the vaccine could eliminate the remaining malignant FL cells, and keep the patients in remission—or permanently cured.



NCI

Cancer vaccine researcher Dr. Larry M. Kwak: "Essentially what we have done is present a tumor protein to patients in such a way that their immune systems recognize it and then destroy any cells bearing that protein."

Peripheral blood containing immune cells was collected before vaccination, and at several times after vaccination, to compare the immune response of T-cells to the tumor antigen. These cells were then tested *in vitro* (in cultures) for their response to tumor Ig, and to the isolated tumor cells themselves. There was significant release of cytokines from 19 of 20 patients' T-cells after vaccination, but not before. Of 6 patients chosen at random, all had CD8 T-cells that could lyse the native tumor cells *in vitro*.

Bendandi and Kwak also wanted to know if the remaining tumor cells were being killed off after vaccination in the patients. For this, they needed a specific molecular marker to use to identify these cells in the body. FL tumors often have a particular genetic rearrangement caused by the swapping of one chromosome part onto another, called a translocation. This can be identified genetically. Therefore, using polymerase chain reaction (PCR) techniques on DNA samples taken from the patients' blood, it was possible to detect malignant cells with this translocation, at a sensitivity of 1 malignant cell in 100,000.

Of the 20 patients, 11 had tumor cells with this translocation. The blood of these 11 patients was studied over the course of the trial, and it was found that on an average of 18 months after vaccination, 8 of these patients had totally cleared the malignant cells bearing this genetic marker from their blood.

The patients were followed clinically for 28 to 53 months, and 18 of the 20 remained in complete remission for an average of 42 months after vaccination—far beyond the average time that FL usually recurs. In the 18 patients with complete remission, all have CD4 and CD8 T-cells that react specifically to the tumor antigen. It was also found that in 15 of the 20 patients, antibodies were also generated against the Ig from the tumor, but that the generation of these antibodies was not necessary for elimination of the tumor cells; in fact, several patients with T-cell responses of both types did not generate antibodies.

An interesting question arises from the success of this vaccine formulation to stimulate CD8 T-cells specific to the tumor. The antigen was delivered in soluble form, free flowing in the blood, so it should be picked up by CD4 T-cells, and antibodies should likely be produced. Because the antigen is not presented on a cell surface on the MHC I receptor, how then did the CD8 T-cells become activated against this antigen?

Part of the answer comes from an important immune cell known as the dendritic cell. Dendritic cells reside in lymph nodes and mucous membranes, and they sample the antigens present in the lymph. They are antigen-presenting cells, and their job is to feed foreign antigens to both CD8 and CD4 T-cells. Dendritic cells have the special capability of being able to present a single antigen on both MHC I and MHC II receptors, priming both the cellular and humoral branches of the immune system.

Also, the vaccine uses GM-CSF, which causes the production of new monocytes and the maturation of more dendritic cells, which may account for the success of this particular vaccine formulation.

Immune Stimulation: The Future of Cancer Treatment?

The entire idea of boosting and retraining the body's immune system to fight cancer was ridiculed by many in the medical establishment for years. Now, the success of the cancer vaccine

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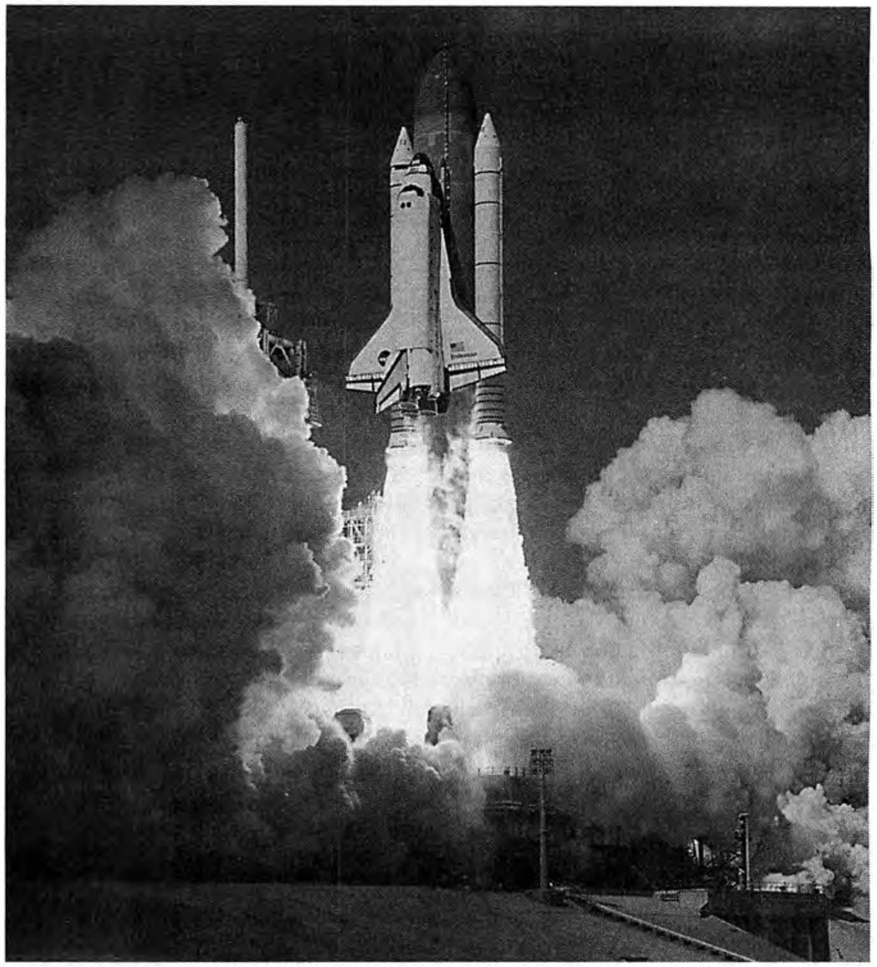
Clinton Ups Budgets For Science, Space

by Marsha Freeman



NASA

Vice President Al Gore's "re-inventing government" scheme has reduced manpower at NASA to the point that the Aerospace Safety Advisory Panel has warned that staff cutbacks, inexperience, work overload, and rising stress levels, have led to safety concerns at the Kennedy Space Center, where Space Shuttles are launched. Here, the Endeavour *takes off on Feb. 11, 2000, for a 10-day Radar Topography Shuttle Mission.*

In his budget submission to the Congress on Feb. 7, President Bill Clinton requested significant increases in funds for the space program, basic science, and biomedical research. For the space agency, in particular, the higher level of funding is critically needed: Thanks to seven years of budget cuts, concerns about the safety of the manned Space Shuttle program have been growing.

In his State of the Union address on Jan. 21, the President pointed out, correctly, that "science and technology have become the engine of America's economic growth." Although he cited the in-vogue "information technologies" as the leading edge of this progress, he did point out that the broader increase in life expectancy, and breakthroughs in understanding "the world around and beyond us" are "the result of government investments in the 1960s and 1970s."

The President announced a $1 billion increase for biomedical research at the National Institutes of Health (NIH), to support research in areas such as diabetes, brain disorders, cancer, genetic medicine, disease prevention, and development of an AIDS vaccine.

The request for the National Science Foundation represents an increase of $675 million, or 17 percent, which is double the largest dollar increase in the Foundation's history. The NSF accounts for half of all non-health university-based research in science and engineering in the United States. The President also announced a National Nanotechnology Initiative of $497 million, to be deployed through a number of agencies, including the Departments of Energy and Defense, the NSF, the NIH, and NASA.

Sorely Needed Funds for Space

The most critical funding increase that the President requested is for the space agency. Over the past five years, NASA became the "poster child" of Vice President Al Gore's "reinventing government" scheme, which was an exercise in cutting federal employment and cutting corners, to "save" money. Although this may reduce office paperwork or "redundancy" in other government departments, at NASA it led to increased risk to the astronauts, and the vehicles that carry them into space.

At his briefing on the fiscal year 2001 budget request on Feb. 7, NASA Administrator Dan Goldin stated that the agency was slated for its first increase in seven years. The $435 million increase, for a total budget request of $14.035 billion, will allow for critical technology upgrades and improvements in the nearly 20-year-old Space Shuttle system.

Three days after the briefing, the independent Aerospace Safety Advisory

Panel released its annual report, restating its concern that manpower cutbacks in the Shuttle program, particularly at the Kennedy Space Center, where the orbiters, fuel tank, solid rocket boosters, and payloads are prepared for launch, were threatening the safety of the system.

The Panel, which was established in 1967 after the Apollo launch pad fire, in which three astronauts were killed, cited staff cutbacks, employee inexperience, rising stress levels from work overload, and obsolete equipment as some of the safety concerns.

The proposed budget for next year will start to remedy this situation, by supporting the hiring of 1,850 new employees, for a net gain of 550 employees for the agency. NASA has been under a hiring freeze for years, and has eliminated about 7,000 jobs to "re-invent" itself.

Kennedy Space Center director Roy Bridges announced that the budget would allow the center to increase its government workforce for the first time since 1994, and hire 158 engineers and technicians to work on the Space Shuttle. Richard Bloomberg, chairman of the safety panel, applauded the increase, repeating that the center was understaffed. "In the general government cutbacks," he stated, "things may have gone too far."

Administrator Goldin also reported that the budget increase would allow 15 new starts in science programs over the next five years, and would increase funding for studies on a next-generation launch vehicle, which will be required to replace the Shuttle fleet over the next 10 to 20 years.

The fiscal year 2001 budget includes an increase from $274.7 million to $302.4 million for the life and microgravity sciences and applications programs. Equipment to outfit the laboratories in the International Space Station will require a ramp-up in funding in these two critical science areas, as will support for scientists who fly experiments on the station.

Nevertheless, there are still serious constraints in the budget. At a hearing before the Space Science & Applications subcommittee of the House Committee on Science on Feb. 16, Administrator Goldin answered a question by Rep. Ralph Hall (D-Tex.) about adding a dedicated Space Shuttle mission next year for science, by explaining that the money for that mission has been directed toward the manpower deficit and the Shuttle upgrades. Rep. Hall pledged to work with NASA to find the funds to carry out science Shuttle missions while the space station is under construction.

Fusion Funding Disappointing

One disappointing aspect of the Administration's budget request is a paltry 1 percent increase in funding for magnetic fusion energy research, even though numerous reviews over the past year have been favorable and urged more support.

However, if one takes into account the fact that the budget for the Office of Fusion Energy Sciences includes an increase of $9.34 million for decommissioning the Princeton Tokamak Fusion Test Reactor, along with waste clean-up costs, the actual research programs are actually down 3 percent to $224.5 million.

After a workshop held in the Washington area Jan. 27-28, 2000, the United States, Argentina, Brazil, Canada, France, Japan, South Africa, South Korea, and the United Kingdom pledged international cooperation to develop advanced fission reactors.

Fission energy also received a small boost. The nuclear fission budget requested by the Administration includes an increase from $22.4 to $35 million for the Nuclear Energy Research Initiative, to explore innovative new technologies in nuclear power production, domestically and through international efforts.

Promising Cancer Vaccines

(Continued from page 71)

in clinical trials has brought about a rethinking of how to go after cancer. After all, the immune system is really the body's best defense against disease, and standard chemotherapy does just as much damage to the cells of the immune system as it does to cancer cells.

Fortunately, there are several cancer vaccine approaches currently in clinical trials. There have been many small trials, mostly phase one, that have shown the potential of this approach. One of the more successful small trials was finished in 1996, using dendritic cells themselves as a sort of vaccine. In this study, led by F. Hsu and R. Levy of Stanford University Medical Center, specific tumor antigens from B-cell lymphomas were fed to the patient's own dendritic cells, which had been grown in culture. These dendritic cells were then injected back into the patient, and a booster shot of the antigen was given again.

All of the patients mounted a measurable immune response against their tumors, and two patients demonstrated complete remission.

Another approach that has been used for cancer vaccines, is to genetically modify tumor cells *in vitro* to produce immune-stimulating cytokines, which are intended to get the tumor recognized as a target by T-cells and other immune cells. This approach has been demonstrated with prostate cancer in a small trial at Johns Hopkins University, led by Dr. Jonathan Simons. Simons's team removed prostate tumors, and then genetically engineered the cells to produce the cytokine GM-CSF. The cells were then irradiated to stop them from growing further, and injected back into the patients. Immune responses and tumor shrinkage occurred in 8 of 11 patients in this trial.

There are many questions to be answered, and many more clinical trials will be needed before cancer vaccines will be used and accepted as a treatment. However, what was once only a concept treated as "quackery" has now proven itself to be an effective and nontoxic way to treat cancer.

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KRIMSKY'S KAOS:

The Hormonal Bias of a Bioethicist

by Stephen H. Safe

Hormonal Chaos: The Scientific and Social Origins of the Environmental Endocrine Hypothesis
Sheldon Krimsky
Baltimore: The Johns Hopkins University Press, 1999
Hardcover, 304 pp., $35.95

The endocrine disruptor hypothesis became news in the mid-1990s, with scare headlines about how chemical pollutants, which mimic the molecular shape of some hormones, were causing sexual dysfunction in the wild (for example, the shrinking of alligator penises in the Florida swamps), lowered sperm counts, and increased male reproductive tract problems.

The book *Hormonal Chaos* by Sheldon Krimsky provides an interesting but limited background on the origins of the environmental endocrine disruptor hypothesis and some of the cast of characters involved in this issue. In his discussion of almost every controversial issue, Dr. Krimsky clearly favors the so-called "hormonal chaos" theory, which holds that synthetic industrial compounds, acting as hormone mimics, are the latest environmental disaster.

Dr. Krimsky interviewed me in Boston after a symposium at Tufts University, regarding my opposition to the endocrine disruptor hypothesis, and he subsequently invited me to speak at a symposium he organized at the Annual Meeting (1998) of the American Association for the Advancement of Science in Philadelphia. The symposium, titled "Environmental Chemicals as Endocrine Disrupters: Scientific Evidence and Public Policy," was one of the most one-sided scientific/policy meetings that I have attended, and my disappointment was communicated to Dr. Krimsky at the conclusion of the meeting.

Dr. Ellen Silbergeld, a professor at the University of Maryland School of Medicine, former director of the Environmental Health Program at the Environmental Defense Fund, and a preeminent environmental scientist and spokesperson, was also invited to the meeting. Silbergeld told me that she was "so disturbed by the lack of balance and nonscientific nature of the proceedings," that she discarded her original presentation on heavy metals and proceeded to provide a more balanced overview on what she called "a hypothesis that's running far ahead of the data."

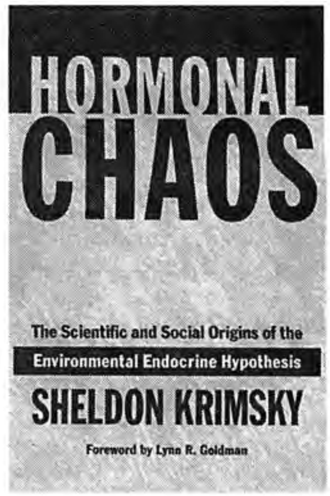
The endocrine disruptor hypothesis is supported by some environmental findings, laboratory animals studies, and human data obtained for women treated during pregnancy with the highly potent estrogenic drug, diethylstilbestrol (DES).[1] Based on these data and a 1992 study reporting a global decline in sperm counts during the last 50 years,[2] it was hypothesized that decreased male reproductive capacity may be associated with increased dietary exposure to estrogenic compounds, and possibly to other endocrine disruptors such as dioxins and the pesticide metabolite DDE (an antiandrogen).[3,4]

In Chapter 1, Dr. Krimsky outlines scientific developments associated with the endocrine disruptor hypothesis and the scientists involved; however, when hormonal chaos is challenged by new data, or by scientists who disagree with the hypothesis, Krimsky becomes defensive and is reluctant to modify his bias. This is an unusual approach by an academic who is a recognized and quoted authority on bioethics.

I discuss here just a few of the controversial issues and how Dr. Krimsky deals with them in his book.

Sperm Count Decline

On pages 26-38, Dr. Krimsky outlines the sperm count issue that originated from a study on the meta-analysis of 61 selected studies, which showed a 50 percent global decline in sperm counts over the period 1940-1990.[2] The only



individuals mentioned in this section are Drs. Sharpe and Skakkebaek, who proposed the endocrine disruptor hypothesis,[3] and Dr. Swan, who supports their analysis.[5]

In 1996, Harry Fisch, a highly respected urologist, and his colleagues published a study in *Fertility and Sterility*[6] showing that geographical location was an important variable in sperm counts. For example: New York is high, at 131.5×10^6/ml; Minnesota is intermediate at 100.8×10^6/ml, and California is low at 72.7×10^6/ml. Fisch is quoted (but not named) as saying, "I can explain all the declines in sperm counts by geographical variability."

Krimsky then goes on to say, "Yet supporters of the sperm decline theory found strength in numbers," and he quotes extensively from 19 scientists who coauthored a report from Denmark and a summary review of this report in the journal *Environmental Health Perspectives*.[7] However, science progresses and, since 1997, several papers from clinics throughout the world have reported that

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The headlines in the national press, as well as the scientific press, in the mid-1990s went wild with speculations about the emasculating effects of pollutants. Newsweek, *March 21, 1994, heralded shrinking alligator penises and lowered testosterone levels, and warned that man could not be far behind.*

over the past 10 to 25 years, there have been minimal declines/increases, or no declines in sperm counts in countries such as Denmark (in Odense and Copenhagen),[8,9] Canada,[10] northeastern Spain,[11] Slovenia,[12] Venezuela,[13] and Australia (Sydney).[14]

Thus, most recent studies do *not* show declines; moreover, the importance of geographical location within both large countries (United States and Canada) and smaller countries (Denmark and France), and sperm count variability, has been demonstrated.[61,10,15,16] For example, among 11 fertility centers in Canada,[10] mean sperm counts in 1996 varied from 43×10^6/ml to 137×10^6/ml, whereas environmental levels of persistent organochlorine contaminants (which are the prime suspect endocrine disruptors) are similar throughout Canada.

In a critical review of the sperm count issue by Saidi and co-workers,[17] the authors state, "When accounting for this geographic difference and examining all available data, there appears to be no significant change in sperm counts in the U.S. during the last 60 years." In addition to the uncertainties regarding demography, and many other factors that can influence sperm counts and quality, Dr. David Handelsman[14] reported that sperm counts in five different groups, recruited from 1987-1994 for five studies at the University of Sydney (Australia), varied from 63×10^6 to 142×10^6/ml! This variability was far in excess of the 50 percent decline observed in the meta-analysis paper.[2] Dr. Handelsman concluded, "This highlights the invalidity of extrapolating similar findings on sperm output of self-selected volunteers to the general male community or in using such study groups to characterize sperm output in supposedly 'normal' men."

In science, hypotheses are proposed and are not considered to be fact until they have been tested. Most of the data noted above were generated, in part, to test the validity of one component of the endocrine disruptor hypothesis, namely, decreased sperm quality/counts, and yet Krimsky primarily quotes articles coauthored by those who initiated or support the hypothesis, and he does not report new scientific developments in the chapter of his book which is aptly named "Scientific Developments."

Dr. Krimsky, and readers of his book, should also note that in a recent study on changes in sperm counts in men from Copenhagen,[9] it was reported that there was some seasonal variability in sperm counts; moreover, from 1977 to 1995, sperm counts *increased* from 53×10^6 to 72.7×10^6/ml. Although motility in the "excellent" category declined, this study shows, the sum of percentages "having excellent or good motility did not decline through the study period." Because this study was coauthored by many of the same scientists (including Dr. Skakkebaek) who published the meta-analysis paper in 1992, we now appear to have gone full circle. This report should at least assure Dr. Krimsky that "all is not rotten in the state of Denmark."

Testicular Cancer and Other Male Reproductive Tract Problems

Dr. Krimsky points out that testicular cancer and other developmental deficits that may be hormonally related (hypospadias and cryptorchidism) may be increasing, but again he fails to cite newer scientific developments in these areas. For example, the incidence of testicular cancer is high in Denmark (14.5 per 10^5) but low in Finland (3.6 per 10^5). It was suggested by Sharpe[4] that the environmental contaminant DDE (identified as an anti-androgen and weak estrogen)[18] might play a role in this disease. Ekbom and co-workers from the University of Uppsala addressed this issue, and reported in the Scientific journal *Nature* that: (a) since the mid-1960s, DDE levels in breast milk have been similar in all Scandinavian countries;

(b) the increase in testicular cancer is paralleled by a 80 to 90 percent decrease in DDE levels.[19]

The authors concluded: "Hence, the persistent differences in the Scandinavian countries in testicular cancer incidence rates in the age-groups exposed *in utero* in the mid-1960s to early 1970s challenge Sharpe's theory. Furthermore, the alleged increase in cryptorchidism, hypospadias, and other urogenital malformations cannot be linked to p,p'-DDE since the concentrations have decreased during the past 20 years."

Although some reports indicate that hypospadias (displaced urethral opening) and cryptorchidism (undescended testicles) may be increasing, a more recent study by Paulozzi[20] on worldwide trends showed that prior to 1985, there were both increases and decreases in these defects, and there were large differences in the incidence of these defects in various geographical locations (a familiar refrain).

It is my impression that Dr. Krimsky deals with most of this new scientific data by not referring to it at all, or by indicating that it can be found on the home page of an industry trade group (pp. 100-101). This is a convenient, but dishonest way to downplay the impact of scientific developments that do not fit his preconceived notions. His constant failure to report significant new findings is more consistent with Krimsky's Kaos than Hormonal Chaos.

Xenoestrogens and Breast Cancer

Dr. Krimsky deals with the breast cancer-xenoestrogen hypothesis (pp. 38-45) by correctly pointing out that a woman's lifetime exposure to estrogens is a major risk factor for this disease. In 1993, Drs. Davis, Bradlow, and coworkers hypothesized that xenoestrogens were a preventable cause of breast cancer in women (p. 40),[21] and this was based not only on the additional burden of estrogen exposure but also (a) on observations that PCBs or DDE (synthetic organochlorine pollutants) levels were higher in breast cancer patients compared with controls[22, 23]; and (b) the effects of organochlorine pollutants and other estrogenic compounds on ratios of the estrogen metabolites 2-hydroxyestrone (2-OHE1)/16α-OHE1.[24]

My involvement in the endocrine disruptor controversy was triggered by the xenoestrogen-breast cancer hypothesis, because my research has been focussed on organochlorine pollutants and phytochemicals in vegetables that exhibit antiestrogenic activity in breast cancer.[25] My opposing views were published and presented at the Society of Toxicology meeting in Dallas (spring 1994), and this resulted in subsequent financial support (1994-1996) from the Chemical Manufacturers Association (CMA) to pursue research in this area.

In contrast to results by Bradlow and co-workers,[24] we showed that the 2-OHE1/16α-OHE1 ratio was not a predictive assay for mammary carcinogens in MCF-7 breast cancer cells.[26] However, Krimsky's comments on our work typify his approach to most data that do not support Hormonal Chaos. First, he states, "Such evidence was purported to have been put forth in a study by Safe and McDougal"; then, he says, not surprisingly, "Bradlow considered the Safe and McDougal paper fundamentally flawed." Krimsky follows this by a disclosure of my funding source for this work (the Chemical Manufacturers Association), with the implied assumption that the results could not be trusted.

He then states, "Safe's role in disputing different components of the hypothesis has also raised eyebrows among some of his colleagues, who consider his industrial funding sources as a matter of dishonor in these sensitive areas of science." In fact, to the contrary, many of my colleagues have been disgusted by the unfounded accusations and have supported and encouraged my speaking out on this issue. As Dr. Krimsky well knows, my views on this subject have not changed prior to, during, or since the loss of my funding from the CMA, and his insinuations are untrue and very disappointing.

Moreover, Krimsky failed to mention a lengthy review of the xenoestrogen-breast cancer hypothesis by a team of eminent scientists from the University of Uppsala, the Karolinska Institute, Dartmouth Medical School, and Harvard University School of Public Health, which concluded, "The hypothesis that human exposure to environmental levels of organochlorines would favor an estrogenic overactivity leading to an increase in estrogen-dependent formation of mammary or endometrial tumors is not supported by the existing *in vitro*, animal and epidemiological evidence."[27] This review of the literature (published in 1995) was also supported by the CMA.

Subsequent studies[28, 29] have also seriously questioned the utility of the 2-OHE1/16αOHE1 metabolite ratio. For example, a study reported in the prestigious *Journal of the National Cancer Institute* in 1999 by Ursin and coworkers on estrogen metabolite ratios in postmenopausal women, concluded, "This study does not support the hypothesis that the ratio of the two hydroxylated metabolite (2-OHE1/16α-OHE1) is an important risk factor for breast cancer." This conclusion comes from members of a highly eminent and experienced epidemiology group at the Comprehensive Cancer Center, University of Southern California. Again, Dr. Krimsky fails to present new scientific developments that were initially reported in 1997.[28]

Organochlorine Pollutants

My final example concerns the role of organochlorine pollutants (DDE and PCBs) in breast cancer, in which Krimsky discusses my editorial comments in the *New England Journal of Medicine*,[30] not in terms of interpretation of scientific data (that is, that there are no increased levels of DDE/PCBs in breast cancer patients compared with controls), but in terms of my failure to disclose prior CMA funding! The journal does not ask for prior funding sources, and at the time of writing the editorial "Safe's funding had stopped," Krimsky says. True to form, he uses a so-called controversy and implied innuendo to dispense with providing the reader with scientific developments on studies that have investigated DDE/PCB levels in breast cancer patients vs. controls.

Results from large patient groups in San Francisco, Rio de Janeiro, Mexico City, five countries in Europe, several states in the northeastern U.S., and Copenhagen* have not shown increased levels of DDE and/or PCBs in breast cancer patients vs. controls.[31-38] One of these studies concludes: "Results from this prospective, community-based nested case-control study are reassuring. Even after 20 years of follow-up, exposure to relatively high concentrations of DDE or PCBs showed no evidence of contributing to an increased risk of breast cancer."[37]

It is possible that some pesticides, in combination with other factors such as polymorphisms of some genes, may play a role in development of, or protection from, breast cancer, and this should be further investigated.

An Unbalanced Picture

In summary, Krimsky has clearly not presented a balanced or updated review of scientific developments on the endocrine disruptor hypothesis with respect to impacts on male reproductive capacity or breast cancer in women. The pattern of subtle innuendoes and obfuscation is unfortunate, and his failure to update himself and the reader on current scientific developments impairs his ability to discuss uncertainty values, scientific responsibility, and policy issues in subsequent chapters.

I agree with Dr. Krimsky that this is an interesting hypothesis that requires testing, and while scientists may disagree on some of the data, there are several issues that need to be resolved. For example, *in utero* exposure to DES provides an important underpinning for the endocrine disruptor hypothesis, and yet, *in utero* exposure to high doses of steroidal estrogenic drugs does not result in the serious DES-like effects in the offspring. Further, it has been reported that after *in utero* exposure, neither DES nor estrogenic drugs decrease fertility of the offspring.[39, 40]

Testicular cancer is increasing, and the environmental (diet, occupation, chemicals, lifestyle), genetic, and demographic inputs to this disease are unclear. Theo Colborn and Bram Brouwer have raised the issue of thyroid hormone mimics and their developmental impacts; differences in neurodevelopmental deficits in various locations and their correlation with timing of chemical exposure and different chemical classes require further study.

This is only a partial list of scientific problems associated with the endocrine disruptor hypothesis; however, the latest scientific developments on these issues have not been adequately addressed by Sheldon Krimsky in his book *Hormonal Chaos.* I suspect he is now hard at work on new bioethical issues for his latest book.

Notes

* This study showed higher levels of dieldrin in breast cancer patients.

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Is There Life on Mars? The Quest Continues

by Marsha Freeman

The Search for Life on Mars: Proceedings of the 1st UK Conference
Julian A. Hiscox , Ed.
London: British Interplanetary Society, 1999
Paperback, 112 pp., $46.00

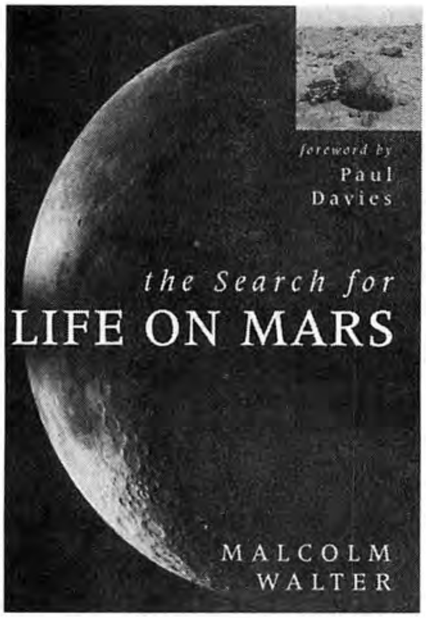
The Search for Life on Mars
Malcolm Walter
Cambridge, Mass: Perseus Books, 1999
Hardcover, 170 pp., $25.00

One of the most profound questions to be answered in the 21st century is whether life has developed anywhere else in the Solar System, or the observable universe. Although it has been recently discovered that water can be harbored in meteorites, and many planetary scientists believe that there is a water ocean under the surface of Jupiter's moon Europa, for centuries Mars has been viewed as the most likely place where we will find life.

These two excellent books review the history of the search for the answer to this question, the missions and experiments planned for the future, and the re-evaluation of the boundary conditions for life, in light of the claims that have been made concerning life on Mars.

The notion that there is, or has been, life on Mars has waxed and waned for hundreds of years. In his presentation to the British Interplanetary Society's Symposium, held in November 1998, Richard Taylor reprised this history. In the mid-19th century, he reports, the popular view of Mars was that it is a miniature Earth. It had been established 300 years before, for example, that Mars has a day that in length is not unlike our own.

Surface features, and polar caps that grew and receded with the seasons, were seen in telescopic observations of the red planet. That life existed beyond Earth was accepted by a majority of scientists by the end of the 19th century, Taylor reports. Then, in 1877, the first great controversy about life on Mars arose, when Italian astronomer Gio-



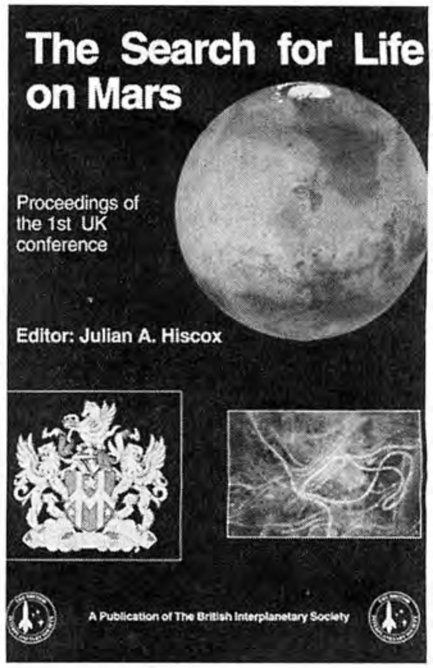
vanni Schiaparelli described the dark banded features that he saw on Mars as "canali."

Mistranslated as "canals," rather than "channels," Schiaparelli's *canali* became, in the mind of American astronomer Percival Lowell, the great architectural works of an intelligent civilization. Most scientists did not doubt there was life on Mars, but life with human intelligence was a fantastic—and disputed—claim.

In the second book reviewed here, Malcolm Walter describes this extrapolation—from what one could actually observe, to a truly fantastic conclusion—with sympathy. After all, the spirit that moved these earlier astronomers not only to observe but also to try to explain, is what moves scientists today.

Walter quotes from Lowell's 1906 book, *Mars and its Canals,* in which Lowell says: "From time immemorial travel and discovery have called with strange insistence to him who, wondering on the world, felt adventure in his veins. . . . To observe Mars is to embark upon this enterprise; not in body but in mind."

As more precise data on the hostile temperature, atmosphere, and other



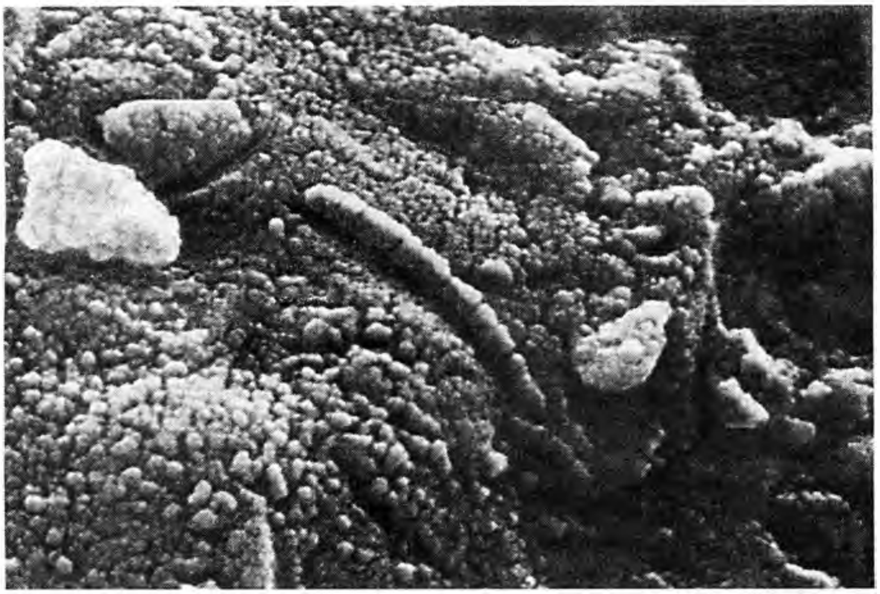
characteristics of the planet were available during the first half of the 20th century, Percival Lowell's intelligent life thesis was dealt a serious blow. But the real shock was to come when the first close-up of Mars emerged, during the space age.

Mars Seen from Space

On the evening of July 14, 1965, the Mariner 4 spacecraft flew by Mars, passing over the equator and then the southern hemisphere of the planet. Not only were there no artifacts from a previous advanced civilization, but the planet below was a combination of bright and featureless desert regions, and heavily cratered terrain. This Mars appeared to resemble not the Earth, but the dead Moon. Suddenly, from a Solar System oasis, Mars turned into a great disappointment.

Later, however, robotic fly-bys of Mars began to reveal some of the dramatic detail of the planet that had been obscured by the earlier lower-resolution imaging. These included the largest volcano in the Solar System, a 3,000-mile-long canyon that would stretch from New York to California, and water ice and frozen carbon dioxide poles that change with the seasons. Outflow channels that could only have been made by vast quantities of flowing water were photographed by spacecraft.

Now, Mars again became a planet with a geologic and hydraulic history, which could have hosted at least primitive life



NASA

This tiny, segmented worm-like structure, found inside Martian meteorite ALH 84001, is highly suggestive of life. Differing interpretations of the evidence that these are the fossil remains of living organisms have spurred lively and heated debate, and pushed forward the field of discovering life in extreme environments.

eons ago, under more benign climactic circumstances than exist today.

With the view that Mars could harbor life, the two Viking landers, which touched down on the red planet in 1976, carried three different experiments to try to test for the presence of life. Because the results were negative, inconclusive, or disputed by different scientists, the first landing of a spacecraft on the surface did not answer the question of whether there is, or has been, life on Mars.

The Antarctica Evidence

Perhaps the most recent controversy over evidence for life on Mars has produced the greatest boon yet to science. In the summer of 1996, a team of scientists led by Dr. David McKay announced that they believed that a meteorite from Mars (ALH 84001), found in the Alan Hills region of Antarctica, contained the fossil remains of a primitive organism.

For the past three years, teams of scientists around the world have been studying the processes by which the specific features of this meteorite could have formed, debating back and forth whether the primary cause was life, or inorganic. The informative paper on the Allan Hills meteorite at the British Interplanetary Society Symposium, included in the book of proceedings, presents a clear, concise, nonhysterical summary of the data, pro and con, and points toward the paths of research that should be followed.

In his discussion of Mars meteorite Alan Hills 84001, although Malcolm Walter reaches the conclusion that the "evidence is unconvincing" that the rock contains fossil remains of life on Mars, he presents "both sides" of the story, in terms of the observations and explanations by various scientific teams. And while he is not sanguine about fossil remains in meteorites, Walter states that "if there ever was life on Mars, there is a good chance it is still there."

One of the criticisms of the team that had proposed meteorite ALH84001 had fossil remains was that there were no known living organism on Earth that are so small—only billionths of a meter. This challenge has led to the search, and discovery, of forms in the nanobacteria range, with the dispute now broadened to a debate on what "living" means.

Likewise, over the past few years, life has been found to thrive in extreme environments, such as extreme cold, extreme heat, high levels of radiation, and so on. The British Interplanetary Society proceedings include material on this important new contribution to the study of terrestrial and extraterrestrial life.

The Search Has Barely Begun

Malcolm Walter, a paleobiologist, has studied fossilized microbes from the earliest of Earth's geological epochs. In his book, he presents an absorbing discussion of the recent revolutionary changes in thinking about the history of the development of life on Earth, and he cautions that "the search for life on Mars has barely begun." He also warns that "this is not a field for the timid, the pessimistic, or the cynical," pointing out that advances "have been won as a result of optimism, vision, and determination."

Walter reprises various theories of the history of the development of life on Earth, pointing out how theories regarding the "tree of life," which indicates a common "ancestor" and then branching off to form major groups and species, had to be changed and discarded as new discoveries were made. This is not a purely academic endeavor, since the life forms we would expect to find on Mars or elsewhere in the Solar System would most likely resemble the primitive start that life had on this planet. Only microbes, Walter reports, existed on Earth at the time that the surface of Mars was habitable.

Both of these books review the current and future missions to Mars that space agencies around the world are now planning, to ultimately lead to the human exploration that will finally answer the question of whether or not life developed on Mars. One fruitful mission approach has been to study regions of the Earth that are analogous to Mars—particularly in Antarctica. Understanding how life can flourish in a cold, dry region such as the South Pole, will shed light on the conditions under which life could potentially still exist, perhaps under the surface, of dry, frozen Mars.

Malcolm Walter ends his book with a quote from Pope John Paul II, in 1998, ". . . it is necessary not to abandon the passion for ultimate truth, the eagerness to search for it or the audacity to forge new paths in the search. . . ."

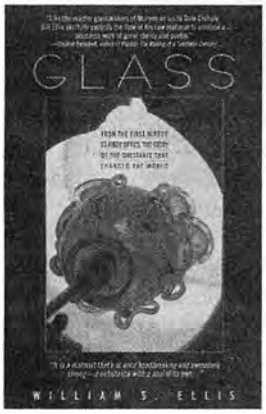
These two excellent publications present a clear and thoughtful summary of the major questions requiring answers, while we continue to develop the tools that will allow us to continue the search for life on Mars.

Looking Through the Technology of Glass

by Elisabeth Pascali

Glass: From the First Mirror to Fiber Optics: The Story of the Substance That Changed the World
William S. Ellis
New York: Avon Books, 1999
Paperback, 306 pp., $14.00

The first two parts of this book are chock full of fascinating technological advances in the glass industry: from the ribbon machine to create lightbulbs, to the method of creating everyday plate glass (do you know how windows are made?), to the various uses of fiber optics. For those, like this reviewer, who grew up technologically ignorant of how common, everyday items made of glass are brought into being, it is very worth reading the first 11 chapters (I would, however, recommend that impressionable minds avoid Chapter 10, which is full of environmentalist cultural pessimism).



The last third of the book, however, is simply a hymn to modern art and its use of glass, and can be skipped without missing much.

William Ellis has worked as an assistant editor and editorial staff member of the *National Geographic* for 27 years, and it shows. Despite its fascinating details of the technology of glass, the book is definitely written as a "coffeetable book." This paperback has one short section of color photographs. The hardcover version, published last year, hopefully has more color photographs to accompany the rambling, vacuous writing style.

It is possible that Corning Glass, or some other industrial source, has a more in-depth version of the truly exciting technological breakthroughs and potential applications of glass, both past and future. Unfortunately, most of the references for further reading given by Ellis concentrated on the artistry section of the book.

Hormonal Bias

Continued from page 77

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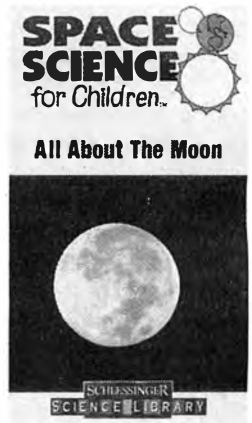
Sloppy Presentation of Space Science

All About the Moon
All About the Earth
All About the Planets
All About the Sun
All About the Stars
Leesburg, Va.: Schlessinger Media, 1999, Videos, 23 min. each, $29.95 each

Nothing is more exciting to young children than to learn about the planet they live on, and the Moon, planets, and stars they see at night. This series of video tapes, while making good use of NASA footage and animation, and of young people carrying out experiments to explain basic concepts, suffers from an apparent inattention to detail which mars the presentation.



Each video tape in this series includes factual errors that will confuse the attentive viewer. For example, the Moon is described as having a "dark side." Although one side of the Moon is always facing toward Earth, the other is the "far" side, which is not dark, but alternates between night and day, just as the face we see does.

Similarly, the statement is made in the video on the planets that the mission operations team could not easily communicate with the Sojourner rover on Mars because of the long communication time. Although it is true that Mars is millions of miles from Earth, the communications time is actually only about 14 minutes.

It is unfortunate that the producers of this series of tapes did not take more care in the accuracy of what is presented.

—*Marsha Freeman*

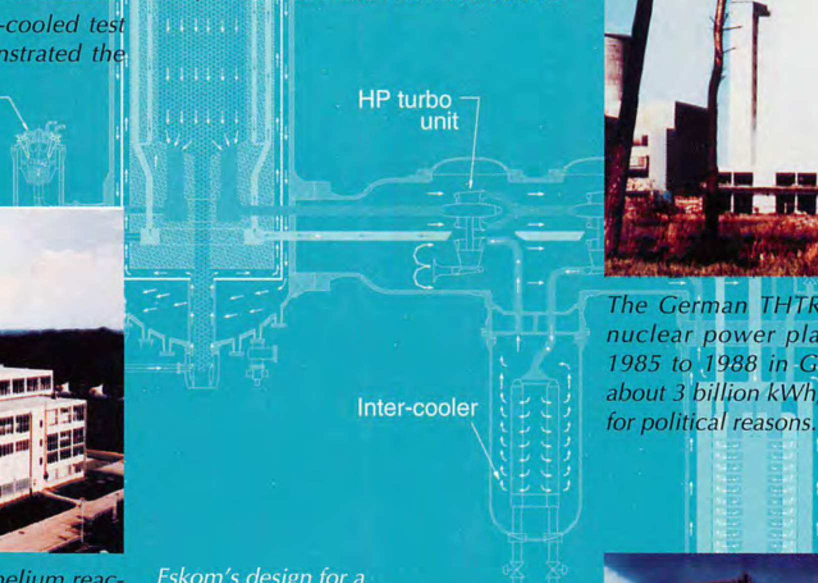
THE HIGH-TEMPERATURE NUCLEAR REACTOR COMES OF AGE

Eskom, the South African utility, has announced plans to mass-produce modular high-temperature gas-cooled reactors, based on the German pebble-bed design; the first reactor is scheduled to go on line in 2005. In the Nuclear Report, Jonathan Tennenbaum describes Eskom's design, and its plan to build as many as 30 modules per year, for domestic use and export.

The high-temperature reactor concept has 35 years of research and development behind it, and Eskom's pebble-bed modular version, the PBMR, makes use of this operating experience, plus new technologies, such as direct-cycle electricity generation by a helium turbine, and inherent safety. As a result, the PBMR is simpler, less costly, and far more efficient than conventional light water reactors (45 percent net efficiency compared to 30 to 35 percent for LWRs).

Photos are courtesy of General Atomics, which is developing a gas-turbine modular helium reactor, GT-MHR, in collaboration with the Russians and others.

Dragon, the British helium-cooled test reactor, 1964-1976, demonstrated the technology.



Eskom's design for a Pebble-Bed Modular Reactor.

The German THTR, a helium-cooled nuclear power plant, operated from 1985 to 1988 in Germany, generating about 3 billion kWh, but was shut down for political reasons.

AVR, Germany's prototype helium reactor operated successfully from 1966 to 1988.

Fort St. Vrain, the U.S. HTR, operated from 1979-1989.

Peach Bottom, the U.S. prototype helium reactor, 1967-1974, achieved 86 percent availability during its electricity-production phase.

In This Issue:

HOW MANY PLANETARY SYSTEMS ARE OUT THERE, AND HOW DID THEY GET THERE?

Conventional theories of planet formation have crumbled in the past five years, as scientists have discovered at least 28 probable extrasolar planets. Each new discovery has required a re-evaluation of assumptions about the evolution of planetary systems. Marsha Freeman describes the astronomers involved in the planetary quest, the new technologies for ground-based observations, and the future missions planned from space.

Space Telescope Science Institute/NASA

A Hubble telescope image of clusters of infant stars that formed in the arms of the barred-spiral galaxy NGC 4314. How many will develop planets?

© Buddy Mays/CORBIS

THE AMAZON COULD FEED MILLIONS

"Saving the rainforest" and "preserving indigenous populations," are popular slogans, promoted by international financial interests who want to loot the natural resources for their own benefit. The other side of the story is forcefully presented by Gilberto Mestrinho, Senator from the Brazilian state of Amazonas, who urges the development of the tremendous agricultural and industrial potential of the region. The Special Report features his speech before the Brazilian Senate, translated from the Portuguese.

Will the Amazon be reserved for the rich—or will its potential be developed to feed Brazil and bring the Amazon population out of poverty? Here two boys and their dugout canoes on the Amazon, as the giant Royal Viking Sky cruises behind them.

Courtesy of Vladimir Voeikov

UNDERSTANDING WHAT DISTINGUISHES LIVING SYSTEMS

The non-reductionist school of biology, pioneered by the Russian biologist Alexander Gurwitsch, is making breakthroughs in investigating the biological function of the weak light emission detected from living cells—including its importance in cancer detection and treatment. Prof. Vladimir Voeikov, a leader in the field, discusses the latest research, presented at the Second International Gurwitsch Conference, held in Moscow in September.

Continued on inside back cover

Prof. Jinn Ju Chang, President of the International Institute of Biophysics (left front) and Prof. Fritz-Albert Popp, the Institute's founder, at the plenary session of the recent international biophysics conference in Moscow.