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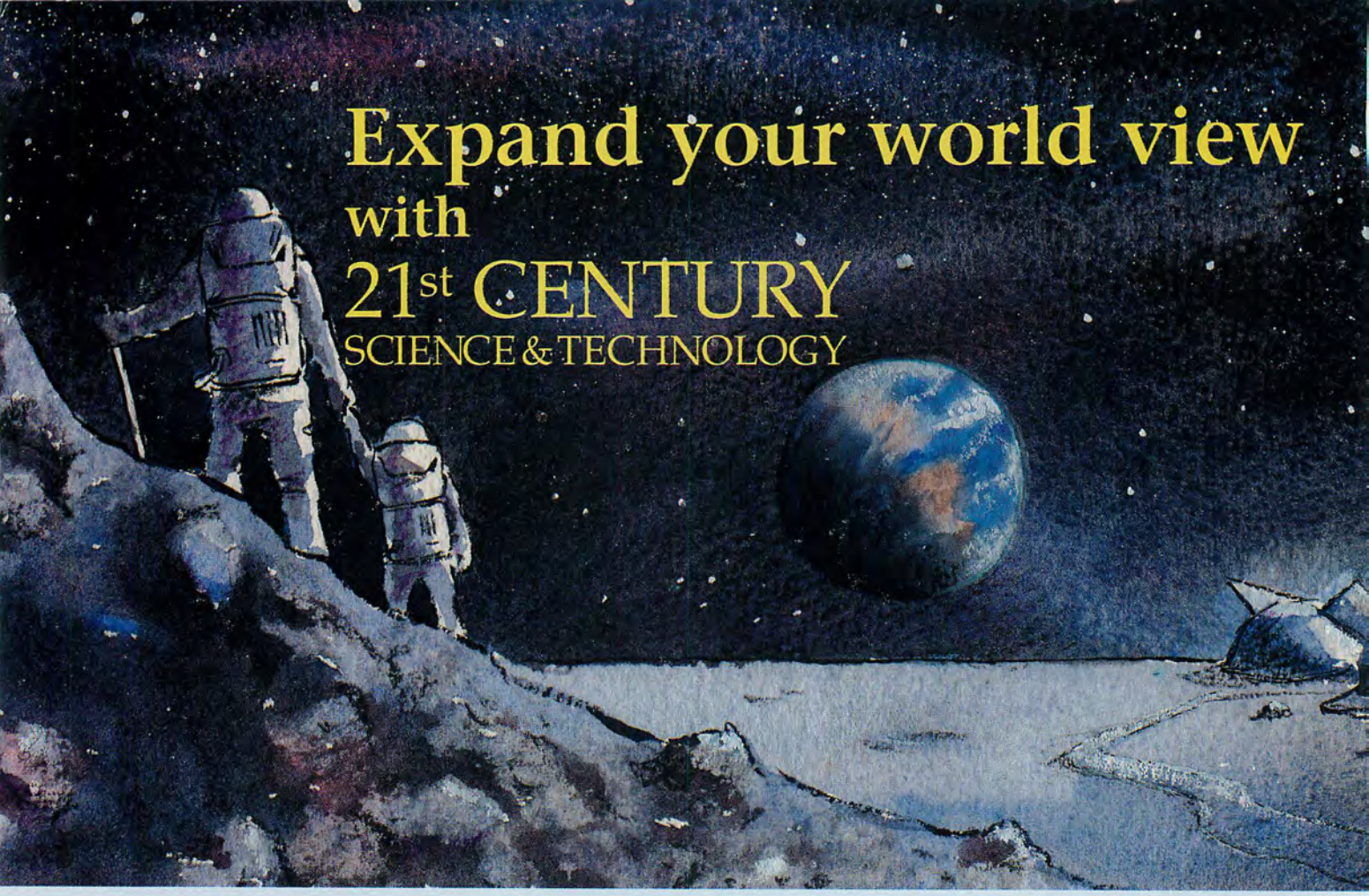

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Vol. 11, No. 2 Summer 1998

Features

19 **Krafft Ehricke's Moon: A Lush Oasis of Life**
Marsha Freeman
Only a grand vision for lunar development will move space programs into the future.

GURWITSCH'S NON-REDUCTIONIST BIOLOGY

34 **Introduction: Alexander Gurwitsch: Father of Biophysics**
Colin Lowry

36 **Alexander Gurwitsch and the Concept of the Biological Field, Part 1**
Michael Lipkind
A student of the great biologist discusses the importance of Gurwitsch's thought and work.

52 **Remarks on Gurwitsch's Method**
Lyndon H. LaRouche, Jr.
An economist comments on the importance of Gurwitsch's method for physical economy, in particular, the spread of pandemics like AIDS.

55 **Simulation of Ampèrian Current Elements By Magnetic Toroids**
Thomas E. Phipps, Jr., and Jorge Guala Valverde
A relatively simple experiment, using U-shaped magnets in a toroidal configuration, demonstrates the existence of Ampère's angular force, which has been written out of physics by Maxwell, Grassmann, Lorentz, and their epigones in today's physics establishment.

Jim W. Grace/Science Source, Photo Researchers

In search of a relatively transcendent physical principle to unite two or more astronomical cycles into a single whole, Jonathan Tennenbaum pursues a geometrical metaphor. See Pedagogy, p. 74.

News

SPECIAL REPORT

15 The 7th International Conference On Cold Fusion: The Latest Word about Cold Fusion
Dr. Edmund Storms

ENVIRONMENT

66 There's No Truth to the Rising Sea-level Scare
Dr. Richard D. Terry
A marine geologist examines the myth that global warming will raise sea levels.

68 The IPPC's Rising Catastrophe Level

PEDAGOGY

74 Revisiting the Simplest Discoveries
Dr. Jonathan Tennenbaum

Departments

2 EDITORIAL

3 LETTERS

6 RESEARCH COMMUNICATIONS
Hawking Radiation Challenged With Far-Reaching Implications
Dr. Mario Rabinowitz

8 NEWS BRIEFS

10 VIEWPOINT
Extraterrestrials Have Never Visited the Earth
Julian Grajewski

83 BOOKS
***The Anisotropy of Space* by Maurice Allais**
Rémi Saumont

88 BOOKS RECEIVED

On the cover: Illustration of Moon colony by Pat Rawlings, courtesy of the Lunar and Planetary Institute; cover design by Rosemary Moak.

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EDITORIAL

Overturn Reductionist Science!

This issue brings together reports on three topics, so seemingly unrelated, according to the conventional schema of science, that it is necessary to call the reader's attention to the hidden, or underlying conceptual thread, which unites them. The three articles are the report by Professor Michael Lipkind on Alexander Gurwitsch's work in biology, Lyndon LaRouche's commentary on Gurwitsch's method, and physicist Thomas Phipps's contribution on the virtual Ampèrian current-element.

The great beauty of the work of A.G. Gurwitsch is that it establishes so clearly, and in so many different applications, that the growth of a living organism cannot be explained by reference to a prepackaged set of instructions located within the individual cell. From the bell-like shape of the chamomile floscule, to the form of the epithelial layer in shark brains, the existence of the whole cannot be explained as the mere sum of of its parts. Comparing one member of a species to another, the parts, (individual cells, groups of cells, or organelles) are never the same, and are often widely different in size, orientation, and ordering; yet, they arrive at the final goal, the whole, which always assumes the shape or form recognizable as characteristic of that species.

But even more remarkably, the individual cells seem to act as if ordered by some agency outside of themselves. Gurwitsch denotes by "biological field" his attempt to conceptualize such an agency.

Yet, we must also recognize that it is only because of the success of our philosophical opponents, the reductionists and mechanists, in imposing their restrictive point of view on all fields in science—biology above all—that Gurwitsch's work appears in any way remarkable. A century ago, it was not so, and even 50 years ago, these were at least, topics of debate. Today, however, biology **is** molecular biology, that is, *reductionist biology*. There is almost no questioning of the axiomatic assumption that all causal relations are ultimately to be explained by the actions of the genetic material, and the assumption that its actions are reducible to something analogous to a computer program, or like form of symbolic logic.

Not without reason, the life sciences were the last to succumb to the onslaught of mechanistic philosophy: that is, the belief that all processes of nature can be explained by resort to *matter* (in the form of irreducible elementarities) and *motion*. Although many today even mistake this for the scientific method, we have shown elsewhere that such a prejudice (imported into England from 16th century Venice), and diffused by such popularizers as Thomas Hobbes, Francis Bacon, and Isaac Newton), was never the basis for discoveries in modern science.[1]

Formalism's Procrustean Bed

Not only is such reductionism unacceptable in the life sciences, but it is equally unacceptable in the so-called hard sciences. Contrary to the usual textbook and popular science accounts, it is only by restricting the domain of applications to the most specialized class of phenomena that one succeeds in fitting the actions of inorganic nature into the Procrustean Bed of sterile formalism, which textbook authors like to call "universal laws."

Thus, André Marie Ampère, by no later than 1825, had demonstrated that the "universality" of the mechanism of the "inverse square law," which seemed to underlie the phenomena of gravitation, static electricity, and magnetism, did not extend to moving current electricity. Here, in addition to magnitude and distance, a dependence on the angular relationship between the elements of current had to be considered. The validity of Ampère's new Force Law was brilliantly established by the collaboration of Carl Friedrich Gauss and Wilhelm Weber over the ensuing two decades. However, owing to the hegemony of mechanistic doctrine, as enforced by such as Clausius, Helmholtz, Lord Kelvin, and Maxwell, the Ampère-Weber Law was suppressed and eradicated from the textbooks.

As demonstrated anew in this issue, by Thomas Phipps, Jr., and Jorge Valverde, Nature is not a studious reader of textbooks. The deeper lesson to be learned, is that nature is not reducible to laws describing "irreducible particles" and their motions. Indeed, the irreducible particles do not exist. Ampère's experimental re-

searches led him not to an irreducible elementarity of electricity, but to an increasingly complex inner structure of matter, which he associated with the concept of the "magnetic molecule." In the hands of Wilhelm Weber, Ampère's magnetic molecule became the basis of modern atomic science, including Weber's discovery, published in 1870 (and also removed from the textbooks), of the nonexistence of the Coulomb repulsive force below a certain critical length.[2]

As LaRouche identifies in the third referenced piece, the source of the persisting error in contemporary science lies not in the stars, but in ourselves. The toleration of reductionist doctrine not only produces error across the spectrum of scientific investigation, from the inorganic to the living domain. It also actually reverses the natural ordering, such that, in the ultimate absurdity of modern "information theory" approaches, the higher-ordered phenomenon of *mind* is explained by the random actions of insensate elementary particles—the billiard-ball theory of mentation.

In LaRouche's contribution, "Some Remarks on Gurwitsch's Method," he presents his unique refutation of reductionism, which emerged as the solution to a crucial paradox of economic science—that is, the relationship of the human mind to the process of expanding physical economic reproduction. The same considerations which occupied Gurwitsch, he tells us, provided a foundation for his solution to the economic problem.

The path of solution lay along the following lines. The evidence of biology provides us with two types of progressive evolutionary series: First, the series of progressively more complex morphogenetic changes in living organisms, sometimes referred to as phylogeny; second, the series of developmental changes in the individual organism, from embryo to adult form.

The evidence of human economy provides us also with two types of evolutionary series: One, the series of successive improvements in mastery over nature, which has expressed itself in a historic increase of the potential relative population density of the human species, from primitive hunter-gathering modes to modern society (The human species distinguishes itself from all other living forms in this regard.) The second developmental series is the succession of progressive, creative intellectual breakthroughs, which we call Art (or Culture), and Science. These, by their nature, must originate in the mind of an individual member of the species, although the conditions which give rise to them are social.

In the first case, that of biology, it is not so evident how one is to account for the progression of the series. In the second case, human economic evolution, or progress, LaRouche recognized that the *motor* for development from one stage to the next, is the creative faculty of the human mind: creative scientific discoveries, socially disseminated and realized as breakthroughs in technology. The virtually massless output of a creative human mind, a new idea, thus becomes the motive force for the successive evolutionary transformations in the biosphere, realized by human society. The analogy or parallel to Gurwitsch's notion of the "biological field" guiding the progressive development of the organism is notable.

The Primacy of Mind

This leads us necessarily to the conception that the hierarchy established by the reductionists' influence over science—that is, physics (even mathematical physics) at the top of the pyramid, followed by the other physical (quantitative) sciences; below them, the life sciences; and at the bottom, the (non-quantitative) humanities—must be overturned. This is not to give credence to the perverse reductionist concoction known as "social sciences." Rather, that a scientific approach to the understanding of nature must dispense with the reductionist prejudice implied by the notion of independent irreducible elementarity, and instead re-adopt the standpoint of primacy of mind which ruled modern science in its better, earlier days.

In this intellectual organizational pyramid of science, at the top stands the science of human mentation, (that is, physical economy) subsuming under it, the humanities, the life sciences, and, finally, the attempt to discover the ordering principle of non-living processes, the so-called hard sciences.

—Laurence Hecht

Notes

1. See, for example, Lyndon H. LaRouche, Jr., "How Hobbes's Mathematics Misshaped Modern History," *21st Century*, Spring 1996, p. 21.
2. See Laurence Hecht, "The Atomic Science Textbooks Don't Teach," *21st Century*, Fall 1996, p. 21.

Fusion: Hot or Cold?

To the Editor:

The purpose of this letter is to point out an inconsistency in the Winter 1997-1998 issue of *21st Century:*

Charles B. Stevens says ("Sandia National Lab Clears Path to Inertial Fusion") on page 27, "Nuclear fusion of hydrogen nuclei to form helium is the source for the energy output of the stars." Stevens goes on to give another pitch for the old, and so-far sterile, hot fusion research program.

Dr. Edmund Storms ("Cold Fusion: An Outcast of Science"), on page 24, reports on Randell Mills's concept of "fractional energy levels [of hydrogen whereby] energy can be released by the formation of collapsed hydrogen atoms called hydrinos." In fact, Mills has stated (*Infinite Energy,* Vol. 3, p. 21) that "the gases around the Sun are 2 million degrees and the surface only 6,000. . . . If the energy is being produced in the core, why is the gas around the Sun hotter?"

Mills hypothesizes that solar energy results from hydrogen atoms collapsing to hydrinos in the extreme heat and extreme low-pressure of the solar corona; and he claims to be able under laboratory conditions to replicate this non-nuclear reaction with a release of many times more energy than the hydrogen-helium nuclear reaction.

One or the other hypothesis may be right; one is undoubtedly wrong. All bets for 30 years and billions of dollars have gone into backing the institutionalized science on the old idea; nothing has been spent on the new. No one apparently had thought of it before. This may be because institutionalized expertise in the science establishment never welcomes, and often suppresses new ideas. *21st Century*'s very name implies its leanings toward new ideas. It should get behind the new ideas and the lone individuals who initiate them. Virtually all progress in science, if not in technology, has been initiated by the intuitions of lone individuals. The institutions with their teams of experts have been a drag in the past and are even more so today.

C. Warren Hunt
Calgary, Alberta, Canada

Charles B. Stevens Replies

I sympathize with the dilemma you pose, and although many may dismiss your polemic as a bit brazen, nevertheless you raise a very interesting question: Is it hot or cold fusion? Actually there is probably only "cold nuclear fusion."

First, however, to the more general questions you raise about what is happening in nuclear fusion energy research and development: It is not the fault of scientists that fusion energy has not been fully developed and implemented throughout the world economy. The Magnetic Fusion Engineering Act of 1980, which called for the development of fusion energy by the year 2000, was ignored. In addition, the chief sponsor of that law, the Fusion Energy Foundation, was illegally shut down and put into forced bankruptcy by the U.S. government in 1987.

Since that time, the development of fusion energy has been systematically suppressed, with the limited exception of those programs that have gotten the support of the military, such as the Sandia and Lawrence Livermore national laboratory inertial confinement fusion programs.

And inertial confinement fusion is far from "sterile." Hydrogen bombs based on inertial confinement generate copious outputs of energy, and could be utilized for propelling spaceships and numerous other peaceful applications. The targets that the Livermore NIF (National Ignition Facility) laser will ignite, and those that Sandia will ignite, have already been tested in underground explosions and are demonstrated to work.

In general terms, however, you are correct: the establishment does suppress science and new ideas in particular.

Now, to your question concerning hot versus cold fusion. Wilhelm Eduard Weber, who together with Carl Gauss built the first electric telegraph in 1833, published the first paper on nuclear fusion. This paper, "Electrodynamic Measurements—Sixth Memoir, Relating Specifically to the Principle of the Conservation of Energy," appeared in English in the *Philosophical Magazine,* 4th Series, Vol. 43, No. 282, Jan. 1872, pp. 1-20, 119-49. Not only does the paper project the existence of nuclear fusion, but it indicates that nuclear fusion can be achieved "force-free," or in more current terms: "cold fusion." (See "The Significance of the 1845 Gauss-Weber Correspondence," by Laurence Hecht, *21st Century,"* Fall 1996, p. 21.)

The Gauss-Weber paper, together with the possibility of cold fusion, were first shown to me by Dr. Robert Moon of the University of Chicago in May 1974. Moon had come to the University of Chicago at the end of the 1920s to carry out experiments to explore the Gauss-Weber approach to nuclear fusion. Moon was going to begin by generating forms similar to what Mills calls hydrinos. But Moon's original work was interrupted by the Manhattan Project, in which he made immense contributions. After the war, it was again postponed by various other programs, until 1974, when Moon joined in the effort to found the Fusion Energy Foundation.

(The original Gauss-Weber fusion effort of the 1830s, by the way, was shut down by the Holy Alliance and the British Royal family when their troops occupied Göttingen University in December 1836 for that purpose, expelling Weber and six other scientists. And although the Göttingen Seven is an infamous case of "academic" suppression in history, it is little known. Even the fact that there is a standing pogrom against the physics of Gauss, is kept pretty much under wraps today.)

Although I cannot prove it, I believe that the discussions that Moon and I had with various scientists in the 1970s and early 1980s, about the Gauss-Weber approach to nuclear fusion, during the time that we helped organize what became the LaRouche Strategic Defense Initiative as announced by President Reagan on March 23, 1983, helped spark the research that led to the so-called "cold fusion" experiments.

In any case, what people call "hot fusion" is probably cold fusion. That is, at the hundreds of millions of degrees temperatures which generate the plasma state in which nuclear fusion takes place, the electrons and ions actually become highly organized, like a superconductor. Cold temperatures, such as those found in cryogenic regimes, are usually taken to mean a minimal level of thermal fluctuations. Ironically, this can also be the case with *high temperature* plasmas. (In fact, this is the key to the great success of the Sandia Z machine exploding wire plasma pinch, which I discussed in the article you commented on.)

We will only begin to comprehend how nuclear fusion really works by ending the 150-year pogrom against the science of Gauss and Weber.

War on Drugs Questioned

To the Editor:

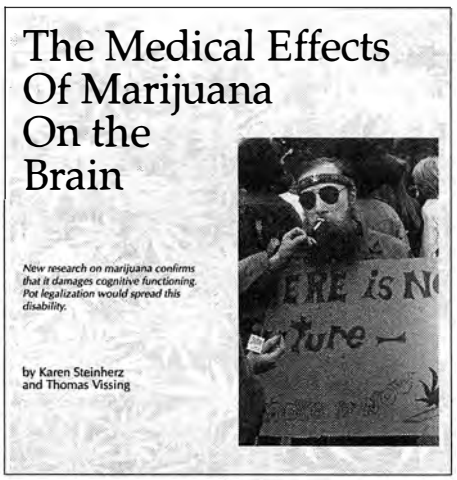
Karen Steinherz and Thomas Vissing ["The Medical Effects of Marijuana on the Brain," Winter 1997-1998, p. 59] may well be correct in their assessment that chronic medical problems arise from long-term marijuana usage. But this does not mean that a society has the right to treat individuals who choose to use marijuana as criminals. Our civilization will surely be looked upon someday as barbaric for its practice of imprisoning citizens who violate social norms (such as this) in private.

Let me make it clear: I am no advocate of drugs. I am a professional scientist, married to a church choir director, with a family of three teenagers to raise. I do not want my teenagers abusing drugs. But over the last few years, news and facts and rhetoric about the national "war on drugs" started catching my attention.

Consider the following:

(1) Drug dealing and enforcement together constitute a several hundred bil-

lion dollar per year business worldwide.[1] We are fueling the world's largest black market, creating a bonanza for drug dealers, and in return our society gets gangs, violence, crime, and corruption.



(2) The government builds costly, overflowing prisons in which victimless offenders can become violent criminals. California, for example, has not constructed a new university campus since 1965. Instead, about two dozen new prisons have been built.

(3) Primarily as an anti-drug offensive, the government has granted itself vast power to seize private property even from innocent people. So if a spouse or a business partner, say, winds up involved in drugs, your share of assets will be taken away from you no matter how innocent you might be. In an amazing ruling, the Supreme Court upheld the right of the government to do just that. A wife lost her share of a seized automobile, because her husband had used it in soliciting a prostitute. That happened not to be a drug case, but no matter, the principle was established, and the "war on drugs" is where seizure is most widely used by the government.

(4) We are appalled when Islamic regimes ban Western books, music, television, clothing, and the like. We consider it outrageous when a repressive government dictates the private behavior of its citizens. And yet, we allow our government to throw our own citizens into prison for things done in private. On what moral or constitutional grounds can we justify controlling the mere possession or private use of something?

We may not want people to be using drugs. But do we really want to give the government the power to incarcerate its citizens for this? This seems barbaric . . . and an ominous road to be going down that threatens all of our rights.

I have, regretfully, come to the conclusion that our national "war on drugs" poses a greater danger to our society than the drugs themselves. Isn't it time to rethink our drug policies from square one? Which drugs are really dangerous? Which are addictive and which are not? Which drugs might even have useful effects?

The citizens of California have voted that marijuana has valid medical uses. Users of MDMA (Ecstasy) report a sense of bliss and euphoric empathy with others. I have read on the Internet about some monks using it successfully to create a transcendent state. Are these things bad? Are these things that people should go to jail for in a civilized society?

Steinherz and Vissing may be medically correct, but their conclusion is morally and ethically wrong.

Bernhard Haisch
Redwood City, Calif.

Notes

1. $53.7 billion was spent on illegal drug purchases in the United States alone in 1996, according to the Associated Press. Add to that a similar amount spent on enforcement.

Karen Steinherz Replies

We understand your frustration that the War on Drugs has not stopped drug traffic. However, please reread the last few pages of our article, because you have missed our point. I can only repeat what we wrote: The private citizen is the *victim* of financier-speculators like George Soros, and other political and financial backers of the international drug cartels, who try to engineer more "soft" drug use, as well as more hard drug use. This is their method of controlling the post-industrial society of the 20th and 21st centuries.

An effective War on Drugs would have to include the following strategic recommendations:

(1) "Shut down the drug money-laundering by the major Anglo-American banks and the dope cartel would choke to death on its own profits." This is the essential message of the book *Dope, Inc.*, published in 1978 by the Executive Intelligence Review. I participated in the research and investigation of *Dope, Inc.*, and its message is as true today as it was then.

George Soros, in fact, is not just a major supporter of marijuana legalization organizations like NORML and the Drug Policy Foundation. He also supports the narco-terrorist apparatus in Latin America which is the absolutely essential military support for the the cocaine producers in Bolivia and Peru. (For references, see *Executive Intelligence Review,* Jan. 31, 1997, pp. 46-65.)

(2) There must be effective intelligence sharing and technical and military logistic cooperation between the United States and the relevant drug-producing nations, without direct U.S. military involvement. For this, I refer you to the current case of Peru which has reduced its cocoa cultivation by 50 percent, with the help of the Clinton administration. For this, I refer you to an article titled "Columbia Must Follow Peru's Strategy vs. Narco-terrorism," by Dennis Small *(Executive Intelligence Review,* May 8, 1998), as a dramatic case in point.

(3) We must mobilize the citizens of the United States through the media to support this war-winning strategy and idealism, instead of the pessimism and pop culture that is spread through American television and news media.

On the Blood Brain Barrier

To the Editor:

The article on "The Medical Effects of Marijuana on the Brain" was generally well written, but one passage stands out: On page 60, the authors state that "Even antibiotics, or drugs for cancer treatment, do not cross this barrier," referring to the blood brain barrier. I would advise the authors to read page 10 of *The Pharmacological Basis of Therapeutics* by Goodman and Gilman, 6th edition, which states that "the barrier is neither absolute nor invariable." In addition, a cursory examination of modern drug therapy demonstrates the great dependence medical care has on the ability of medications to cross this barrier.

Kervin Glick, Reg. Pharm.
Lihue, Hawaii

(Continued on page 7)

Hawking Radiation Challenged With Far-Reaching Implications

by Mario Rabinowitz, Ph.D.

By means of gravitational field emission, radiation may be emitted from black holes in a process differing from that of Hawking radiation, which has proven elusive to detect experimentally. This new theory can lead to an understanding of the universal gamma-ray background and gamma-ray pulsars. Minuscule black holes herein are candidates for the missing dark matter of the universe, and possibly even some ball lightning.

Although black holes were long considered to be a fiction, they now seem to be firmly established. In our own galaxy, and in the galaxy NGC 4258, the central dark mass is accepted as a black hole. In the case of our galaxy, recent measurements of the velocities of stars as close as 5 light days from the dynamical center imply a black hole of 2.6×10^6 solar masses.

The concept of black holes whose gravitational attraction is so great that not even light can escape, can be traced back to John Michell in 1783. A century later, in 1916, just two months after Einstein published his basic equations of General Relativity in a short communication, Schwarzchild derived a spherically symmetric solution of Einstein's relativity for an uncharged black hole of mass M with no angular momentum, which he sent to Einstein for submission. It is remarkable not only that Schwarzchild did this so quickly, but that he did it while fatally ill with pemphigus, contracted while on active combat for the German Army.

Although Hawking radiation appears to come from a black hole and finally depletes its mass, its source is from the uncaptured member of a particle pair in the region of space just outside a black hole. Tunneling radiation originates from within a black hole and tunnels out as a result of the field of a second body (in contrast to Hawking's single body approach). This is similar to electric field emission of electrons from a metal by application of an external field. A mutually orbiting black hole and second mass will produce a lighthouse effect for an observer who will detect well-timed gamma-ray pulses when the black hole, orbiting mass, and observer line up.

Rabinowitz in 1992, addressing the physics department at Virginia Commonwealth University on Gödel's Proof and what is allowable in physics.

Hawking deals with a single isolated black hole because that is what the Schwarzchild solution represents. The general relativistic solution for a black hole in the presence of other bodies has not been derived as yet. An isolated body is an idealized abstraction. In the real world, there are no isolated bodies.

Despite industrious searching, Hawking radiation has not been observed. Tunneling radiation can be emitted at much higher temperatures in the present epoch than Hawking radiation, and thus may be able to fit the detected gamma-ray background and serve as a model for gamma-ray pulsars. A gravitational interference effect for black hole radiation, similar to the Aharonov-Bohm effect, is also possible. A second body accomplishes two things. It lowers the barrier and gives the barrier a finite, rather than infinite, width.

The Implications

These small black holes are quiescent compared with Hawking's. Since they are extremely massive for their minuscule size, they may well explain the missing mass or so-called dark matter of which ~95 percent of the universe is composed. Because they can be small compared with the wavelength of visible light, they will not scatter or occlude light from the distant stars. For example, black holes between 10^{-4} gm and 10^{22} gm have radii between 10^{-32}cm and 10^{-6}cm = 100 Å radius, well below visible wavelengths. (For comparison, the mass of the Sun is 2×10^{33} gm.)

To account for the missing dark matter there would need to be between 10^{36} and 10^{61} such black holes. For our universe of radius 15×10^9 light-years, this would require a density of between 10^5 and 10^{31} black holes per cubic light-year—orders of magnitude larger than permitted for Hawking's extremely radiative black holes. That many of his black holes would fry the universe.

The radiated power from a black hole derived in the new theory is:

$$P_R \approx \left[\frac{\hbar c^6 e^{-2\Delta\gamma}}{16\pi G^2}\right]\frac{1}{M^2} \propto e^{-2\Delta\gamma}P_H,$$

where $e^{-2\Delta\gamma}$ is the transmission probability for photons and neutrinos out of a black hole, and P_H is the Hawking radiation power. This implies that the smallest mass that can survive up to a time t is:

$$M_{small} = \left[\frac{3\hbar c^4 \langle e^{-2\Delta\gamma}\rangle}{16\pi G^2}\right]^{1/3}[t^{1/3}].$$

Thus, the smallest mass that can survive within ~10^{17} sec (the age of our uni-

verse) is

$$M_{small} \geq 10^{15} \langle e^{-2\Delta\gamma} \rangle^{1/3} gm.$$

For Hawking, all black holes less than 10^{15} gm would have evaporated by now. Inasmuch as $0 \leq e^{-2\Delta\gamma} \leq 1$, an entire range of black hole masses, much smaller than 10^{15} gm, may have survived from the beginning of the universe to the present, than is permitted by Hawking's theory. For example, if the average tunneling probability $\langle e^{-2\Delta\gamma} \rangle \sim 10^{-15}$, then $M_{small} \sim 10^{10}$ gm and these bodies will presently radiate at $\sim [10^{15}/10^{10}]^2 = 10^{10}$ times more power than a 10^{15} gm black hole with the same $e^{-2\Delta\gamma}$.

In Hawking's popularizations, he clearly takes the position that the radiation does not originate from within the hole, but comes from the vicinity outside a black hole, only appearing to come from within. Thus, it seems clear why Hawking concludes that the information that entered the black hole can be forever lost. If Hawking radiation does not come from within the hole, then it does not really reflect what is inside as the hole evaporates away, shrinking down to zero mass and zero radius. On the other hand, energy conservation, classical and quantum mechanics are violated if the information is lost. Tunneling radiation may resolve this enigma, because this radiation comes from within the hole and carries attenuated, but undistorted, information from within.

As a young man, I was captivated by Hawking's bold vision of light from a black hole, and wanted to see if I could derive the same effect, but didn't get around to it for 24 years. I am grateful to my son Dan for rekindling my desire to do it. Thanks also go to my wife, Laverne, and my friends Yeong Kim and Felipe Garcia.

Mario Rabinowitz, a physicist, was the first person to show that a nuclear electromagnetic pulse cannot black out the United States. He has more than 130 published papers and 33 patents in wide-ranging fields, and he has been an adjunct professor at several universities.

Letters

(Continued from page 5)

The Author Replies

We stand corrected.

You have raised an important point, namely the physics and chemistry of how substances cross barriers in our bodies. We need more scientific activity along those lines, as indicated in the section of our article addressing the role of membranes in cannabinoid activity.

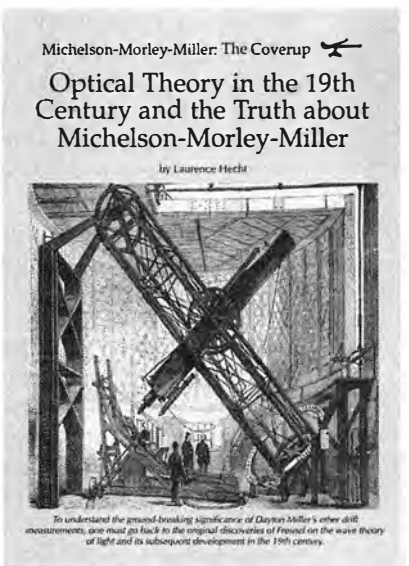
Looking for the Ether Drift

To the Editor:

21st Century published an article by Laurence Hecht on ether drift theories ["Optical Theory in the 19th Century, and the Truth about Michelson-Morley-Miller," Spring 1998, p. 35]. I read it with interest thinking of experiments that would prove or disprove the existence of an entrainable ether. Here is one that came to mind.

Suppose you have a reflecting surface on the Moon. Suppose there is a 200m/sec motion of the solar system through the ether, perpendicular to the plane of the ecliptic. Since the Moon is about 1.5 light seconds away, if you can see the reflector, it is actually 300 miles "north" of where it appears. If you shoot a laser at its apparent location, the laser hits the Moon 600 miles "north." As a result, assuming the laser beam diameter is small, you never hit the reflector and never get a signal back from the laser pulse.

There are, in fact, three such reflectors on the Moon. One each was placed during the Apollo 11, 14, and 15 flights. (See http://www-sn.jsc.nasa.gov/expore/data/apollo/Part1/LRRR.htn)



The LRRR stands for Laser Ranging Retroreflector. My memory says problems occurred with the Apollo 11 experiment. But it is clear from the above URL and related URL's that the Apollo 14 and 15 installations were successful. Laser light was successfully bounced off of the device from Earth. The purpose of the experiments was to determine the distance between the Earth and Moon accurately and to identify variations in that distance due to "wobbling" of the Earth and Moon.

Thus, I conclude that there is very little movement of the Earth-Moon system with respect to the postulated ether. A deeper analysis of the experiment should be able to put a numeric upper-bound on the movement. Unfortunately, that material was not located online, though sites can be found at the NASA web pages.

Max M. Stalnaker
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Laurence Hecht Replies

It's an interesting idea, and certainly worth a closer look. Be sure you go beyond "reported data" to closely examine the experimental setup. Here, the devil is in the detail (and in the assumptions embedded in their interpretation). In general, the idea of utilizing our aerospace capability to reproduce the Michelson-Morley-Miller, and other fundamental experiments relating to light and gravitation, such as Allais's paraconical pendulum, is a very good one.

In the near future, it should be possible to move beyond the heliosphere entirely. An automated laboratory, located perhaps 100 A.U. away from planet Earth, poses all sorts of interesting possibilities for fundamental research in physics, astronomy, and other sciences.

As an upcoming article will reveal, we have had the plans to produce an nuclear-explosion-powered rocket (the Put-Put of Project Orion) that could realize such a dream, on the drawing boards since the 1950s. Surely, it's time to unleash such capabilities now.

PM's cover story: The Ice Age could be here in as little as three years, according to the geological evidence.

GERMAN POPULAR SCIENCE MAGAZINE FEATURES COMING ICE AGE

"In 30 years, the next Ice Age will begin." This is the title of the cover story of the June issue of the German-language popular science magazine, *P.M. Interessante*. The cover shows a picture of Munich's cathedral with an iceberg looming menacingly in the background. *P.M.* is the most widely read popular science magazine in Germany. The article, by Peter Ripota, refutes the global warming scenario, focussing on sunspots, precession of the Earth's axis, and the Milankovitch cycles as an explanation of climate change. In particular, Ripota discusses the recent book *The Manic Sun,* by Nigel Calder, which covers the work of Danish scientists on the moderating effect of the solar wind on cosmic rays, the main generator of cloud cover.

Ripota concludes: "As long as we . . . confuse the virtual world of computer simulation with reality, then a possible catastrophe is heading our way. And it could mean the end of our civilization."

ECOTERRORISM EXPOSED IN CONGRESSIONAL HEARINGS ON CRIME

"We are here to consider the growing and extremely disturbing problem of violent acts by radical environmental organizations, or 'ecoterrorism,'" stated Rep. Bill McCollum, a Florida Republican who chaired hearings of the House Subcommittee on Crime, June 9. McCollum, who is sympathetic to green causes, warned that "we will not tolerate domestic terrorism in the name of Mother Nature." Among the witnesses were California congressman Frank Riggs, whose office was stormed by Earth First!; private investigator Barry Clausen, author of *Walking on the Edge—How I Infiltrated Earth First!;* and Ron Arnold, author of *EcoTerror: The Violent Agenda to Save Nature.*

FOR ONCE, *THE NEW YORK TIMES* HAS SOMETHING RIGHT

An editorial titled "Setting the Sextant Aside," reports that the U.S. Naval Academy announced that it will drop its course on celestial navigation, because "it has been antiquated by modern satellite-linked computer systems." "Perhaps the Navy has put a little too much faith in the redundancy of its electronics and too little faith in the valuable human redundancy of teaching midshipmen a self-reliant and time-tested means of finding their way across open water," the editorial notes. "[A]lmost anyone would prefer to find himself in the lifeboat with a celestial navigator and a sextant aboard rather than the one carrying a navigator—minus computer—who had been instructed only in satellite navigation."

Marjorie Mazel Hecht

Dr. Setlow (right) with astrophysicist Dr. Sallie Baliunas, at 1996 congressional hearings on the ozone hole hoax.

CANCER-CAUSING RAYS ARE ULTRAVIOLET A, NOT UV-B

Depletion of the global ozone layer may not lead to more melanomas, because the most cancer-causing rays, ultraviolet A, already pass through the ozone layer, which blocks only ultraviolet B, according to the research of biophysicist Richard Setlow, Associate Director for Life Sciences at the Brookhaven National Laboratory in New York. As reported in the *Brookhaven Bulletin,* May 8, Setlow said that "about 90 percent of sunlight's melanoma-causing effect may come from UVA and only 10 percent from UVB." Sunscreens don't always prevent skin cancer, Setlow said, because they block UVB, and this may be the reason for the steady, annual 5

percent rise in melanoma rates among whites. Melanoma is a cancer of pigment-producing skin cells, which is expected to strike 41,600 persons in 1998.

LAROUCHE MEETS WITH COLD FUSION SCIENTISTS IN ROME

A group of Italian scientists, including *21st Century* scientific advisory board members Giuliano Preparata and Francesco Celani, met with Lyndon H. LaRouche, Jr. in Rome April 4, for a wide-ranging discussion on scientific research and the frontiers of science. The first subject was the cold fusion work of Martin Fleischmann and Stanley Pons, and remarks by LaRouche against the idea that you can linearize in the small. "As you get smaller and smaller in the interval of observation, the assumption that things become linear in their relations is absurd. The smaller and smaller you get, the *less* linear they've become," LaRouche said.

A transcript of the meeting is featured in *Executive Intelligence Review,* May 1.

EIRNS

Lyndon H. LaRouche, Jr. (left) at the Rome meeting with scientists, April 4.

NEW CANCER TREATMENT USES MODIFIED CHLOROPHYLL

Dr. Avigdor Scherz, of Israel's Weizmann Institute, presented his research on photodynamic therapy for cancer, at the National Academy of Sciences in Washington, D.C., May 19. Scherz has developed a modified form of a bacterial chlorophyll, which absorbs near-infrared light frequencies, and emits toxic free radicals that kill cancer cells. His discovery solves two problems that had hindered photodynamic therapy: By using near-infrared light, the penetration into tissue is greater—about 3 cm—allowing larger tumors to be killed. (Previous compounds penetrated only about 1 millimeter.) Also, the new bacterial chlorophyll is water soluble, and is flushed out of the body in 16 hours, leaving no toxic residue.

In experiments with mice and rats, injection of the modified bacterial chlorophyll, followed by immediate exposure of the area to near-infrared light, resulted in the complete destruction of small tumors. In larger tumors, the photodynamic therapy kills the tumor by destroying the blood vessels that feed it, resulting in cure rates of 75 to 80 percent for melanoma and sarcoma in rats. Clinical trials in human beings will begin within a year.

UNEP AND PRINCE PHILIP'S GREENS: HOW CLOSE CAN YOU GET?

Klaus Toepfer, new head of the United Nations Environment Program (UNEP), intends to bring Prince Philip's green groups "closer to the policy-making process," as he moves UNEP into taking a "stronger role" in overseeing how member countries carry out the U.N. treaties related to conservation. According to a report in *Nature* magazine May 14, the former German environment minister has Prince Philip's International Union for the Conservation of Nature (IUCN) and the World Wide Fund for Nature (WWF) at the top of his list. "I want to be as close as possible to organizations such as IUCN, and WWF," Toepfer is quoted as saying.

*N*ature reporter Ehsan Masood notes, "The role of IUCN may be particularly controversial, as many of its members appear to see conservation as more important than development."

Extraterrestrials Have Never Visited Earth: A Socratic Narrative

by Julian Grajewski

In 1981-1982, I and a friend, Chris Dietz, team-taught a series of classes on Platonic ideas at Cochise County Community College, in Bisbee, Arizona. This is a copper-mining town, 5 miles from the Mexican border, which by the 1970s, had acquired an alternative component including a number of "trust-babies" with time on their hands.

We wanted to assure our students that there was a method by which one could distinguish between opinion and truth, and we wanted to introduce them to the study of philosophy in general. After months of earnest and arduous study, we thought that the core of our rather fluid class membership had a grasp of what Platonic philosophy meant, and what it could do.

The biggest stumbling block we encountered was the pragmatic, practical ideology which intellectually disarms so many Americans (in Aquarian Bisbee, this sometimes took the form of varieties of mysticism, the flip side of pragmatism), and makes any serious discussion of philosophy difficult, especially Platonic philosophy. The dialectical process, which views reality not as a thing-in-itself, but as a relationship, is difficult for a person afflicted by the Sergeant Joe Friday syndrome ("The facts, ma'am, just the facts!"). Equally, any hint that ideas precede "facts," and not the other way around, is "intuitively" dismissed.

With Plato, we were dealing with a philosopher who had been dead for 2,400 years and whose written dialogues were dated. We cast about for a way to update him. We challenged our students to consider a problem which offered little or no material evidence, and one in which the testimony of witnesses was insufficient, contradictory, unreliable, or otherwise suspect. This was the way to challenge the nominalist bias expressed as pragmatism in the United States. Since we were at the end of months of studies, I wanted a problem which had entertainment value. "Lighten up," Chris and I told ourselves. We settled upon the topic of unidentified flying objects, appropriate for a town like Bisbee which, among its charms, has a contingent of saucer devotees and was mentioned in the film "Close Encounters of the Third Kind."

Our formal title for the topic was, "If Socrates or Plato were alive today, what would either make of a UFO report?" Having now given this presentation approximately 60 times, I find that, to carry out such a discussion, I have to sketch the history of Western philosophy and give an outline of constructive geometry—one of the techniques Plato used to make philosophy sensuous. Here is the basic presentation.

Plato Vs. Nominalism

Briefly, there are two traditions of Western philosophy: One is the Platonic tradition, which has also been called Humanism, Idealism, or Realism. Of course, none of those words holds the meaning for contemporary Americans that it would for a philosopher of the Platonic tradition. Today, a humanist is confused with a humane person, and is popularly viewed as a "do-gooder." In reality, a humanist is a person who has rigorously educated himself, or herself, to understand what the best interests of the human species are. We should think of the great Renaissance humanists who were city builders and city dwellers. Today, however, among the educated, humanism is the movement that is specifically anti-clerical and focusses on toleration and cultural pluralism. Idealists are seen as starry-eyed people who do not have both feet on the ground; whereas, actually an idealist is a person who believes in the power of ideas.

Likewise, a realist is seen as a person who has a grasp of the practical, who may be cynical of human motives, but is a "man of action." In Platonic philosophy, however, a realist is a person who does not trust his five senses, because he knows that behind the concrete, there are the forms of the concrete, which can be apprehended only by applications of reason.

The other tradition of philosophy is the nominalist one. This tradition is headed by Aristotle who, of course, was a pupil of Plato, who, in turn, was a pupil of Socrates. The two traditions are by no means strictly separate, more so because of Aristotle's habit of applying Plato's terminology to his own purposes. However, broadly speaking, the term nominalism harks back to William of Ockham, and the word itself refers to the Latin *nomina,* which means naming. A nominalist suspects that ideas have no power to change the universe, and are named and considered for the purposes of discussion only.

There have been, and still are, many varieties of nominalism. Positivism comes to mind; so do the utilitarian outlooks of philosophers like Jeremy Bentham. In economics, we have Adam Smith's *The Wealth of Nations,* which is a thoroughly nominalist work. French existentialism is likewise. So is John Dewey's pragmatism. Politically, fascism is nominalist. But what concerns us here most, is the American ideology: the down-to-Earth, commonsense approach, the practicality, the quickness to action of Americans, which speaks of a thorough distrust of theory.

The Method of Plato

Plato was a pupil of Socrates, who never wrote anything down. After Socrates' judicial murder in 399 B.C., Plato founded his academy, and his fame spread widely. One of the ideas he discussed was that of the philoso-

pher-king. A king, if he were to be a good ruler, must be educated in the rigors of philosophy. Dionysius of Syracuse, a Sicilian tyrant, heard of this and invited Plato to come to teach him how to be a wise philosopher-king.

Plato had misgivings; he was aware of the corruption and brutality of most rulers of the time, but he could not pass up the chance to put his ideas into practice. He came to Syracuse, was dined and feted, and then proceeded to educate Dionysius. However, for weeks and weeks, Plato would only teach Dionysius constructive geometry, although Dionysius kept asking him to teach him to be wise. Instead, Plato continued to teach him constructive geometry, until Dionysius became thoroughly disgusted and had Plato sold into slavery. Some years later, his son, Dionysius II, invited Plato over again. And for the second time Plato travelled to Syracuse. This time, he was nearly assassinated by jealous advisers to the younger Dionysius.

What kind of geometry was it that Plato taught, that nearly cost him his freedom and life?

A Reasonable Geometry

If we look at a high school geometry book, we notice that it starts with definitions which build up to a complete system. A line is defined as an infinite number of points. A point is the intersection of two lines. We notice immediately that we have a circular definition—an absurdity at the beginning of the system, which should bring the rest of Euclidean geometry into question. Sadly, it usually does not, because most students unquestioningly accept givens.

Is there a more reasonable geometry? Plato would say, "yes." He would not start with a point or a line, but with a circle. By finding its diameter, or folding it in half, we have a line. By folding it twice, we have the intersection of two lines which makes a point. We can also inscribe in it all other plane figures, and by spinning the circle we have a sphere in which can be inscribed any solid figure. By slicing a conical section of the sphere, we can generate the self-similar spiral, which leads to higher mathematics.

But, one might ask, why is a circle more rational than a point or a line? Because the circle is the answer to a question—the interaction of two things. In this case, the two things are: what figure can give (1) the greatest area with (2) the least perimeter? Any other plane figure of the same perimeter would have less area. This property of the circle is called the isoperimetric principle. Going further, any solid figure would hold less volume than an equivalent sphere. The important thing here, again, is that we have forced our minds to move from viewing a thing-in-itself, such as a point, to pondering a relationship, which initiates a self-conscious thought process and never accepts arbitrary givens.

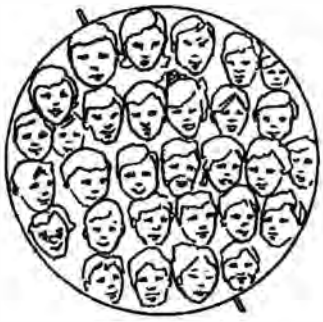
Freedom Equals Necessity

In our classes, we reasoned together by a chain of implications. UFOs in our skies suggest extra-terrestrial intelligence. (There are other possible explanations: for example, Kenneth Arnold, the man who started the UFO craze, now believes that the nine disks he observed flying at 1,200 miles per hour across the face of Mt. Rainier, Washington, were a previously unknown biological manifestation. Others suspect that he was looking at wingtip reflections of a formation of P-80 "Shooting Stars," which, in 1947, were the latest jet fighters.) If so, such intelligence is not to be found on the planetary bodies of our solar system.

Human beings have visited the Moon; Soviet and American probes have landed on Mercury, Venus, and Mars; and fly-bys have been conducted to Jupiter, Saturn, Uranus, and Neptune. In 1986, a probe even crashed upon the tiny, black nucleus of Comet Halley. No life, not even living microbes—never mind sentient beings—has been found.

We surmised that, if the aircraft that Kenneth Arnold saw were crewed by alien pilots, these pilots would have had to have come from another solar or star system. The nearest star, the Proxima Centauri system, is more than four light years away. (A light year is the equivalent of 6 trillion miles.) Statistically speaking, these pilots probably would not have come from the nearest stars—one with suitable planets would probably be tens or hundreds of light years away—an even more stupendous distance. With our present technology, it would take hundreds and thousands of time years to cover such distances.

We quickly dismissed one of the standard plots of science fiction—whereupon thousands of people embark in giant spaceships and live and die in space between the stars until they reach their far-flung objective. Even today, such a course would be morally and psychologically unacceptable—not to mention intellectually devastating to those sent on such a pursuit, and equally to those who sent them, never to be seen again. Suspended animation would also be ruled out as even less acceptable.



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No, we agreed that these would be linear, nominalist techniques for interstellar travel. A dialectical solution would be to marshal the resources of the entire species and invent superluminary travel.

Of course, superluminary travel today is not even theoretically possible. Relativity theory states that a material object travelling at the speed of light would acquire infinite mass. Time dilation effects also come into play, with all their absurd possibilities. Supposedly, nothing in nature can move faster than the speed of light.

To respond to all this, we turn to philosophy, and posit the question that freedom equals necessity, and that when a sentient species arrives at the point that superluminary travel is necessary, the science and technology required will be developed.

Intelligence Has Infinite Potential

At this point, we stood back and took a deep breath. How would Plato proceed? We agreed that Plato's approach would be encompassing and fundamental. He might ask what the rate of development of such a civilization would be. In the accompanying figure, the population growth and energy utilization rate of the human species as a whole is plotted as two exponential curves.[1] To prove that aliens have never visited the Earth and, therefore, that UFOs cannot be the craft of an alien civilization, Plato would use the entire knowledge and experience of the human species from its inception to the present, which is succinctly presented in this graph. Let us examine it.

Although the figure does not show it, we may ask how many hunter-gatherers were on the surface of the Earth, let us say 15,000 years ago? We find (from anthropological studies), that the Earth could not support more than 10 million hunter-gatherers. There simply would not be enough game, nuts, roots, fruits, and herbs to support a greater number. We can see that if the population curve could be plotted back far enough, it would show a long and steady rise until approximately 10,000 or so years before present. At that time, the population rose 13-fold over a dramatically short period of time. Ruins of cities such as Jericho in present-day Israel, the West Bank, and Catal Huyuk, in what is now Turkey, are found with few antecedents; they seem to suddenly be there.

At the same time, energy consumption more than doubled, from the 5,000 or so kilocalories used by our caveman (3,000 from eating and perhaps 2,000 from cooking with fire, the one energy source available to him), to 12,000 kilocalories per person per day.

Potential Relative Population Density

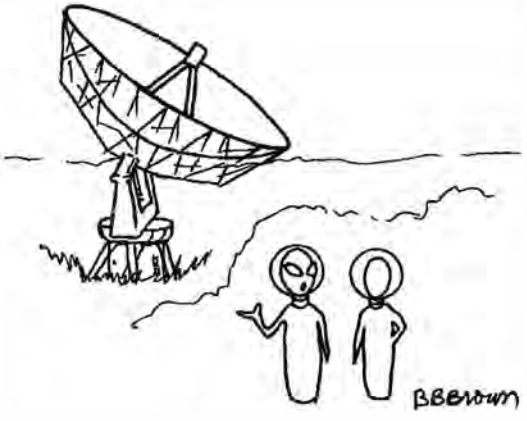
How did this energy and population "explosion" occur? What made 130 million human beings possible on the surface of the Earth? Obviously, it was the invention of agriculture and the domestication of animals. By capturing solar energy via the cultivation of grains, a lot more food became available, and assured, from year to year. Population density increased, and cities became possible and, soon, necessary.

Other inventions followed: hydro-engineering, metallurgy, weaving, roads, ships, better weapons, and the science of astronomy were developed. In spite of negative developments, such as the spreading of warfare at many social levels, and the honing of superstition and magical practices (which, in some cases, led to human sacrifice and infanticide even as late as the Carthaginian culture), the population increased until, during the Renaissance the globe counted 700 million people, each utilizing an average of 70,000 kilocalories daily.

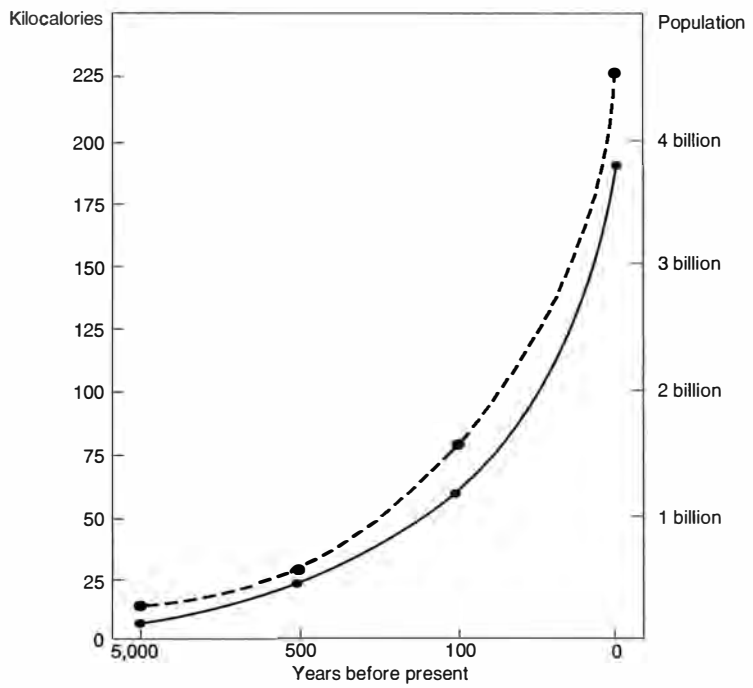
During 1986, the population broke through the 5 billion mark. If we add up all the energy used by the human species in all its multifarious activities, such as eating, agriculture, manufacturing, power production and consumption in ships, aircraft, computers, lighting, air conditioning, heating, maintenance and building of roads, military uses, space programs, scientific enterprises, research, and innumerable other categories, the figure comes to roughly 250,000 kilocalories per person per day. Of course, this is an average, and the rich in rich countries use far more than the poor everywhere. It is easily seen that peasants in some African and Latin American countries are often lucky to consume 12,000 kilocalories daily—what an average human being consumed 10,000 years ago!

Far more interesting than these statistics, is how they look when plotted on the graph. The amazing thing *is that* here, today, with technology nowhere at the level where superluminary travel would be even theoretically conceivable, where perhaps a solar system economy (colonization and terraforming of, let us say, Venus, Mars, and some of the moons of Jupiter and Saturn), begins to look possible, our population and energy utilization are approaching 300,000 kilocalories per person per day.

Here is where I pause, and ask how many people there would be if the plotted curves were to touch the present axis, or approach it very closely? Those who have taken an algebra course struggle with upwardly increasing figures (Carl Sagan's billions



"DID YOU LEAVE THE ANSWERING MACHINE ON? I THINK WE MISSED THEIR CALL."



ENERGY CONSUMPTION AND POPULATION POTENTIAL

The process of scientific invention through the course of human history, has produced an exponential increase in per capita energy consumption (dashed line), showing that secular increases in human population-potential produced by scientific and cultural progress more than offset the increases in population (solid line). In the modern period, the introduction of fossil fuels and, most recently, nuclear energy, has rapidly increased the energy density available for further progress.

and billions!) until infinity is first tentatively suggested. *The staggering fact is that today, we are on the threshold of infinite population growth and energy use.*

Proof Positive

At this point, we might imagine Plato or Socrates pausing and sitting back (of course, in circa 2,400 years before the present, chairs were yet to be invented), to let all this sink in. They might smile, and then ask: "Now, what does all this have to do with flying saucers? Why does all this prove that aliens from outer space have never visited Earth?"

Well, Socrates would certainly ask the fertile question now. If aliens are visiting our home Earth, where would their civilization be on this graph? At what technological juncture would superluminary travel place them? If one extended the time axis and the two curves 20 miles straight up, the curves almost vertically punching through the ceiling of the classroom and the roof of the building to reach the stratosphere, where skies are blackening, our visitor's population and energy utilization figures would be stupendous—practically at the infinity point. So, we would have a species of aliens spreading throughout the galaxy, and perhaps spreading to other galaxies *ad infinitum.*

What would *necessarily* occur when these beings reach Earth?

Well, let us step back again, this time to June 24, 1947, at 3 p.m. On that day, Kenneth Arnold, a civilian pilot, was looking for a downed DC-4 Air Force cargo aircraft. It was then that he saw the nine flying disks spreading across the face of Mt. Rainier, to be promptly dubbed "flying saucers." I submit, and so would Socrates and Plato, were they alive today, that if sentient alien beings from another star system were piloting these saucers, then by 3:42 p.m., our own civilization would have been advanced by them beyond recognition! That this did not happen, demonstrates that extraterrestrials have never visited the Earth.

Dialectical Method

At this point, my "proof" is usually met by a profound, puzzled silence. Quickly, a number of objections are raised. The first one is that alien cultures would not necessarily follow our mode of development. The idea of trillions and quadrillions of beings, whether human or otherwise, is daunting, especially in this age where the notion that we have a "population problem" has been internalized by many. Some biology students point out that population figures for animals and bacteria show the characteristic bell-shaped curve, where exponential growth is followed by equally exponential extinction. Answering these objections involves pointing out that human beings are *sentient* beings and therefore can alter their environment to suit their needs by applications of science.

Likewise, it is objected that resources are finite and, therefore, cannot support infinite growth. I answer this objection with the story of fractional distillation. In the 19th century, oil was not an energy resource. Pennsylvania farmers would feed gobs of crude oil to their sick cows as a purgative. The oil was gushing out of the ground for millions of years, but it did not become a resource until chemistry was developed to the point that oil could be distilled into fuel. To a caveman, a stone might be sharpened into a spear point or thrown as a missile—limited uses for a resource finally exploited thousands of years later by Hittite metallurgists. That rock may have existed for four or five billions of years before it was smelted into iron.

There is enough fusile deuterium in a gallon of seawater to release the equivalent energy of 300 gallons of gasoline in a thermonuclear reactor of the near future. The deuterium has existed since the beginning of the universe, perhaps 15 billion years ago; yet, it is still to become a human energy source, one that could not be imagined until the 1930s. Thus, only if

resources are viewed in nominalist isolation can they be considered finite. Viewed dialectically, as an interplay between a raw material and technological sophistication, we find that the resource base is predicated upon the cultural and technological level of society.

I insist upon the close connection between population growth and scientific innovation (already apparent in the figure), by asking why a gasoline engine was not invented at the time of Plato? Is there a reason that it was instead invented 2,300 years later? Yes, there simply were not enough human beings, enough brain mass, enough division of labor, enough social stimulation, to generate an oil economy until the 20th century! Some students nod affirmatively at this latest example of dialectical reasoning.

The readers of science fiction among the audience then ask, why would the alien visitors have to contact us and develop us? Why could they not maintain a scientific detachment? Perhaps they see us as too primitive to interact with them in a meaningful way? Perhaps we are too warlike for them, and they would decide to shun us? I suggest that sentience is a universal (a Platonic concept). Once a being achieves sentience, it can be taught to interact with any other sentient species in the remaining universe or cosmos. Sentience, intelligence, creativity, are by definition infinite in scope and effect. Thus, all sentient beings are joined in this infinity.

Freedom Equals Responsibility

The uniqueness and preciousness of human life becomes apparent, for, at the infinity rate of development, each and every sentient being becomes important to every other sentient being; no one's ability or life can be wasted or diminished. In such a social geometry, it is probable that the loss of even one life, by accident, murder, or war, may prove catastrophic to the entire species, because the contribution that that life would have made would have been vital. One can even abstract this concept into an index (much as insurance companies do with actuarial tables), and state that the cumulative loss of lives represented by the miseducation of an individual, or his relegation to a menial function, or one even slightly less in accord with his potential, could also prove disastrous.

For example, the contemporary practice of undereducating women and paying them lower wages would be prohibitive. So would most of today's jobs be considered a lethal waste of potential: salespersons, stockbrokers, investment bankers, insurance agents, hamburger flippers, soldiers, manual laborers, advertising executives, secretaries, management consultants, waiters, real estate agents, politicians, grant writers, drivers, systems analysts, etc. Useful jobs would be those of scientists, engineers, technicians, skilled workers (such as machinists who perform the vital function of translating a blueprint into cut metal), teachers, writers, musicians, artists (who, if they are good, increase the self-consciousness of the species and foster overall creativity), explorers, pilots, and perhaps other categories of employment we have yet to dream of.

The degree of social coherence of a superluminary civilization would have to be stupendous. Today, there is much wishful thinking about the possibility of extrasensory perception and telepathy. These abilities are theoretically possible (after all, our brains are electrical transmitters), but realizable only in a society with much greater social cohesion and a need for rapid and efficient communication among individuals (instead of our present anarchic one).

Today, claims of repeatable telepathic communication (chance ones may occur occasionally as our billions of brain cells may very rarely transmit and receive signals at the proper power and frequency), are simply evidence of nominalistic thinking. However, in a superluminary culture, they would necessarily be an every moment event. In such a culture, every kind of life-enhancement would have to be practiced: its citizens would have to be practically immortal; crime and war would have to be abolished; new sentient beings would have to be discovered on other planets; all physical processes would have to be mastered, including planet, star, and galaxy formation, and, ultimately, even the creation of new universes. Here we must be aware of the dictum that we cannot predict with our present consciousness, what our future consciousness will be, and thus there will be now-unimaginable "ultimate" necessities.

To bring everyone back down to Earth, I name one practical advantage (in spite of my diatribes against nominalism and pragmatism) of this dialectical proof that aliens have never visited the Earth: At the moment, Carl Sagan [now deceased], et al., are spending millions of dollars to set up radiotelescopes to listen for possible alien signals. If what I have discussed holds, then this is a waste of time, money, and effort: Any sentient beings in other star systems (*unless they* are very close), would be advancing so rapidly, after having discovered radio, that they would arrive at the Earth well ahead of any signals they might have transmitted years previously!

Julian Grajewski is a prison law librarian in Arizona. He has published works of fiction, poetry, and literary criticism, and has been a high school teacher and community college instructor. His involvement with the ideas of Lyndon LaRouche dates back to 1975.

Notes

1. The concept of potential relative population density was developed by economist Lyndon H. LaRouche, who has used it not only to explain the historical rise in population, but also to warn, from the early 1960s, of the dire consequences (especially in terms of population collapse) of turning our backs on scientific and technological progress. Advances in civilization result from both increases in the quantity of kilocalories available per person, and in the intensity, or flux density, with which that energy can be generated and/or applied.

   Think of the way that a laser with the same power as a 100-watt lightbulb can cut, drill, and weld metal; it is not simply the amount of energy, but also its organization. LaRouche's breakthrough in physical economic science was realizing that the only real source of new wealth was the creative reason potentially present in every human mind. For a full discussion of potential relative population density see *So You Wish to Learn All About Economics: A Text on Elementary Mathematical Economics*, by Lyndon H. LaRouche, Jr., 1st ed. (New York, N.Y.: New Benjamin Franklin House, 1984), chapt. 2.

THE 7TH INTERNATIONAL CONFERENCE ON COLD FUSION

The Latest Word about Cold Fusion

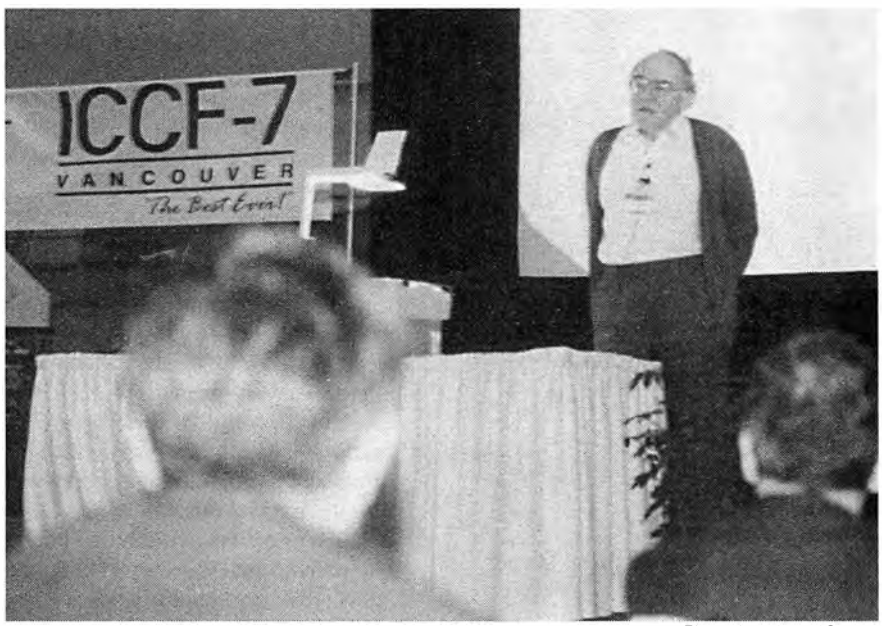
by Dr. Edmund Storms

In spite of many expectations and predictions to the contrary, the phenomenon known as cold fusion is alive and well. Once again, a small but determined group of scientists held their regular conference, this time in Vancouver, Canada, April 19-24. Twenty-one countries were represented by 211 registrants, who contributed 76 presentations. Even the television media were present, this time in the form of one cable channel and two freelance companies, each of which finds an interesting story in following this field, and its struggle with conventional science.

Over the years, the story has grown more complex, on the one hand, and more simplified on the other. What started as a proposed fusion reaction between deuterium nuclei—hence, the name cold fusion—has now expanded into claims for a variety of nuclear reactions (transmutation) being produced in special solid materials, under conditions totally at odds with current expectations. Thus, the phenomena are being renamed chemically assisted nuclear reactions, or CANR.

In addition to being a potential source of clean energy, the phenomena can be proposed as a means to detoxify radioactive materials. This increased complexity has overwhelmed the credulity of supporters and emboldened skeptics. Adding to the difficulty has been the frustratingly hard job of reproducing some claims. As a result, while beneficial implications for society are growing, support for the field is shrinking.

For example, the New Hydrogen Energy (NHE) laboratory in Japan has shut down after failing to find a path to commercial development, the amazing early discoveries made in India at the Bhabha Atomic Research Center are not being pursued, and the careful work at Stanford Research International (SRI) in the United States is being cut back. At the same time, work in France, China, Russia, and Italy is continuing and, in some cases, expanding.



Photos by Edmund Storms

Martin Fleischmann addressing the conference on "Cold Fusion: Past, Present, and Future."

These shifts have resulted from the simplification process. Most early studies concentrated on the claims and method pioneered by Professors Stanley Pons and Martin Fleischmann. Unfortunately, their method has been discovered to be very difficult to reproduce, because of the very complex nature of palladium deuteride, the material in which the fusion reaction is proposed to occur. Without reproducibility, skeptics could not be persuaded, and funding could not be justified—hence, resources were not available to solve the considerable problems associated with achieving reproducibility.

Ironically, much of the limited funding was used to satisfy skeptics, rather than trying to understand the basic nature of the phenomena. As expected, these efforts have been shut down for the time being.

New Results

Fortunately for the field, many other techniques and materials have been found to produce reproducible results. For example, Dr. Roger Stringham, of E-Quest, Inc., has developed a method to load hydrogen isotopes into various metals using ultrasonic cavitation. He claims very high reproducibility, heat production from a variety of metals including palladium and silver, and continued heat production after the ultrasonic energy is turned off. A similar "life-after-death" has been seen by Professors Pons and Fleischmann, as well as by other re-

Roger Stringham (right), E-Quest Sciences/First Gate Energies

Tom Claytor, Los Alamos National Laboratory

Akito Takahashi of Osaka University (right) and Swe-cai Chen of National Tsing Hua University, Taiwan

searchers using other techniques and materials.

Stringham also detects formation of numerous other nuclear products, including helium, especially at regions in the metal which show indications of melting.

The newest results were presented from a method developed in Russia (at LUCH), by a team including Drs. Alexander Karabut and Irina Savvatimova. This method loads various metals with hydrogen isotopes obtained from an electric discharge in gas. Heat production is found to be consistent with the amount of various nuclear products detected. Although high reproducibility is claimed, the method has not been duplicated outside of Russia.

After the initial discovery of Prof. Yosiahki Arata, of Osaka University in Japan,

The Evidence for a Nuclear Reaction with CANR Energy Production

Of the many examples that can be used to support CANR, the measured relationship between energy production and amount of detected helium is the most compelling to many people. Such a study offers special persuasion, because it shows a correlation between two independent measurements; it can demonstrate that a nuclear product is associated with energy production; and, if the claims are believed, it shows the amount of energy produced by each nuclear reaction—a number that suggests the type of reaction involved.

Significant helium production has been reported by 6 independent studies,[1-6] but only Dr. Melvin Miles of the Naval Air Warfare Center, at China Lake, Calif.,[4] and Dr. Benjamin Bush of the University of Texas, with work done at Stanford Research International,[5] have taken the extra steps to obtain a quantitative measurement, using many samples. Such a broad study allows the considerable uncertainty of each measurement to be reduced by averaging many such measurements. It also demonstrates that the proposed relationship cannot be obtained from chance alone.

An additional indication of a strange reaction is the frequent observation of low-energy X-rays only when anomalous energy is being made. The Miles-Bush work was featured at a well-attended workshop at ICCF-7.

Both studies use similar procedures but different calorimeter designs. Miles used a very sensitive isoperibolic calorimeter and Bush used an absolute Seebeck-type. A gas-tight electrolytic cell is placed in the calorimeter for the energy measurement, and current is applied until the infrequent anomalous energy is seen. The evolving gas is passed through stainless-steel tubing into a metal flask (300 cc), which can be sealed at the end of the study.

Once excess heat is observed, the gas mixture of D_2 and O_2 is allowed to flush through the gas-handling system, while a constant current is applied to the cell. After all impurities have been flushed from the system, and heat production becomes constant, the flask is sealed. The flask is then removed and helium in the contained gas is measured, using a sensitive mass spectrometer after the other gases have been chemically removed.

This measurement has been carried out by two different laboratories, with results as shown in the figure, page 10. The excellent agreement between two independent studies, and the internal consistency within each data set, strongly support the conclusion that helium is associated with heat production. However, the helium values are below those expected for a D-D fusion reaction, possibly because some of the helium has been retained within the palladium.

Looking for Errors

One should take the role of the skeptic, as many have done, and explore the role of error. First of all, heat is being measured using a calorimeter in which the gases are not recombined back to D_2O (deuterium oxide). Therefore, the amount of energy production can be overestimated, if unknown recombination should occur within the cell.

This possibility has been eliminated by measuring the amount of gas being produced and the amount of fluid being lost during the study. If no recombination occurs, the amount of D_2O lost from the cell will have a known relationship to the amount of applied current, a relationship which is always found to be present during the reported studies. Therefore, in spite of concerns expressed by Dr. Steven Jones et al., at Brigham Young University,[7] recombination cannot be a source of error.[8]

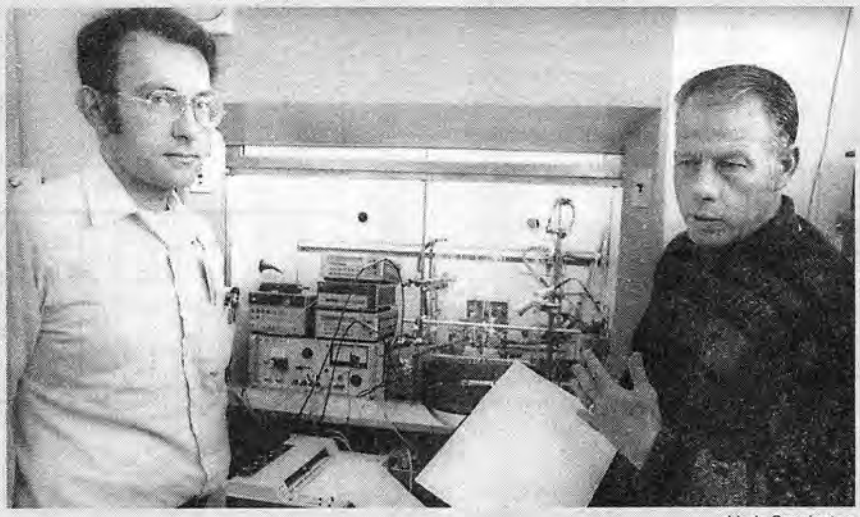
Calorimetry at the low power levels experienced during these studies is always difficult. As a result, the uncertainty in this measurement is large. However, all of the occasions when excess energy is seen always result in a significant helium signal—with one exception: when a palladium-cesium (Pd-Ce) alloy is used. Although this exception is still a mystery, it does not distract from the reality of helium production. Except for the very few occasions when a leak was present in the flask, the absence of heat was followed by the absence of helium.

Miles concludes that such a result would have 1 chance in 760,000 of being caused by random chance alone during his study.[8] When the Bush data are considered, this probability is even smaller. On the other hand, the helium content might be too high because an air leak can admit air containing the normal 6 parts per million of helium. This possibility is eliminated by measuring the presence of argon or neon in the gas, two gases which would also arrive with the air.

Although only a few samples have been examined in this manner, it is safe to say that the procedure does not normally permit entry of air. In addition, any leak sufficient to add important amounts of air would have to be large, because the gas in the flasks is slightly above normal atmospheric pressure. Gas would have to diffuse into the flask through the leak, or be transported by a small pressure difference, both being slow processes. Such leaks would be expected to cause large, random variations in helium content that are time dependent—a behavior that is not seen.

Helium has nearly the same mass as D_2, and hence can be mistaken for this gas in a mass spectrometer. This error is eliminated in two ways. A high-resolution mass spectrometer is used, which can clearly separate these two masses, and the D-2 is removed from the gas by a chemical process, which does not change the helium content. As a result, helium can be detected and accurately measured at the 1 part per billion level.

A great deal of care has been applied to all aspects of these measurements.



Linda Sappington

Ben Bush (right) and Melvin Miles, with their cold fusion apparatus at the Naval Weapons Center.

Therefore, if an open-minded approach is taken, it is hard to find explanations that would negate the conclusions. Nevertheless, attempts to publish this work and reviews of the entire field have met resistance from conventional scientific journals. As a result, detailed information is still largely unavailable to the general public and to interested scientists.

Notes

1. D. Gozzi, R. Caputo, P. L. Cignini, M. Tomellini, G. Gigli, G. Balducci, E. Cisbani, S. Frullani, F. Garibaldi, M. Jodice, G. M. Urciuoli, "Excess Heat and Nuclear Product Measurements in Cold Fusion Electrochemical Cells," *Proc. Fourth International Conference on Cold Fusion, Lahaina, Maui, Dec. 6-9, 1993.* EPRI TR-104188-V1 (1994), published by Electric Power Research Institute 3412 Hillview Ave., Palo Alto, Calif. 94304, Vol. 1, p. 2.

   See also, *ibid.*, D. Gozzi et al., "Helium-4 Quantitative Measurements in the Gas Phase of Cold Fusion Electrochemical Cells," Vol. 1, p. 6. Also, F. Cellucci, P. L. Cignini, G. Gigli, D. Gozzi, M. Tomellini, E. Cisbani, S. Frullani, F. Garibaldi, M. Jodice, and G. M. Urciuoli, 1996."X-ray, Heat Excess and ^{4}He in the Electrochemical Confinement of Deuterium in Palladium," *The Sixth International Conference on Cold Fusion, Progress in New Hydrogen Energy, Oct. 13-18, 1996, Hokkaido, Japan* (Ed., M. Okamoto), Vol. 1, p. 3.
2. E. Botta, T. Bressani, D. Calvo, C. Fanara, and F. Iazzi, "Measurements of 4He Production from D_2 Gas-Loaded Pd Sample," *The Sixth International Conference on Cold Fusion, Progress in New Hydrogen Energy, Oct. 13-18, 1996, Hokkaido, Japan* (Ed., M. Okamoto), Vol. 1, p. 29.
3. Y. Arata and Y-C. Zhang, 1995. "Achievement of Solid-State Plasma Fusion ("Cold Fusion")," *Proc. Japan Acad.*, Vol. 71, Series B, p. 304. See also, Y. Arata and Y-C. Zhang, 1992. "Reproducible 'Cold' Fusion Reaction Using a Complex Cathode," *Fusion Technol.* Vol. 22, p. 287; and "Achievement of Intense 'Cold' Fusion Reaction," *Proc. Japan Acad.*, Vol. 66, B (1990), p. 1.
4. M.H. Miles, R.A. Hollins, B.F. Bush, J.J. Lagowski, and R. E. Miles, 1993. "Correlation of Excess Power and Helium Production During D_2O and H_2O Electrolysis Using Palladium Cathodes," *J. Electroanal. Chem.*, Vol. 346, p. 99. See also: M.H. Miles, and B.F. Bush, 1994. "Heat and Helium Measurements in Deuterated Palladium," *Trans. Fusion Technol.*, Vol. 26, No. 4T, p. 156. M.H. Miles, B.F. Bush, and K.B. Johnson, 1996. "Anomalous Effects in Deuterated Systems," Naval Air Warfare Center Weapons Division, Report #NAWCWPNS TP 8302, Sept. 1996, 98 pp.
5. B.F. Bush and J. J. Lagowski, 1996. "Nuclear Products Associated with the Pons and Fleischmann Effect: Helium Commensurate to Heat Generation, Calorimetry and Radiation," *The Sixth International Conference on Cold Fusion, Progress in New Hydrogen Energy, Oct. 13-18, 1996, Hokkaido, Japan, (Ed., M. Okamoto), Vol. 2, p. 622.*
6. *L.C. Case, 1998. "Catalytic Fusion of Deuterium," The 7th International Conference on Cold Fusion, Vancouver, Canada, April 19-24, 1998.*
7. *J.E. Jones, L.D. Hansen, S.E. Jones, D.S. Shelton, and J.M. Thorne, 1995. "Faradaic Efficiencies Less Than 100% during Electrolysis of Water Can Account for Reports of Excess Heat in "Cold Fusion" Cells,"* J. Phys. Chem. Vol. 99, p. 6973.
8. M.H. Miles, 1998. "Reply to 'Examination of Claims of Miles et al. in Pons-Fleischmann-Type Cold Fusion Experiment,'" *J. Phys. Chem.*, Vol. 102, p. 3642.
9. M.H. Miles and K.B. Johnson, 1996. "Heat and Helium Measurements Using Palladium and Palladium Alloys in Heavy-Water; Progress in New Hydrogen Energy," *Proc. of the Sixth International Conference on Cold Fusion, Hokkaido, Japan, Oct. 13-18, 1996,* (Ed., M. Okamoto), Vol. 1, p. 20.

who loaded finely divided palladium (palladium-black) with deuterium, Dr. Les Case, of Fusion Power, Inc., described the easy production of excess energy using finely divided metals deposited on activated charcoal (hydrogen catalyst materials). This form of microcrystal appears to be easier to handle and more robust to energy production than is the fine powder used by Arata. Significant helium, the expected nuclear product, was detected. Methane, the expected chemical product from the charcoal, was not produced. An early attempt to reproduce the claim appears to be successful, and more studies are planned.

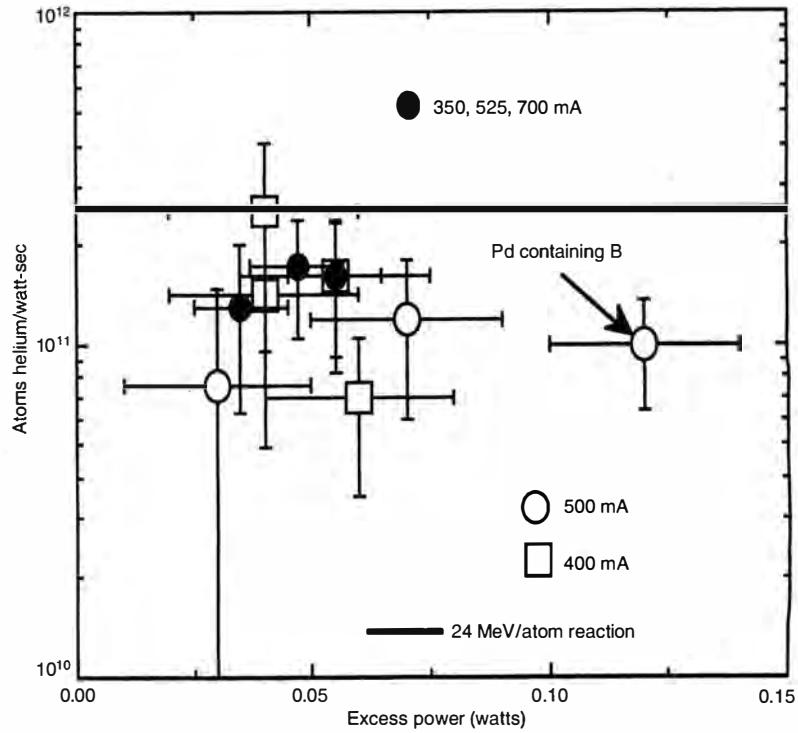
Each of the methods noted above now offers a practical demonstration of energy production, and, hopefully, will be explored by independent researchers.

Transmutations Found

The transmutation branch of the field continues to expand as researchers take the trouble to search their samples for unexpected elements. Prof. George Miley, of the University of Illinois, and Prof. T. Ohomori of Hokkaido University in Japan, presented more details of their continuing, careful work to identify nuclear transmutation products, using metal electrodes electrolyzed in ordinary water. The obvious explanations involving contamination and analytical error, are gradually being eliminated.

Results using a particularly successful method developed by Stan Gleeson, of The Cincinnati Group, were described by Dr. Francesco Celani, of the Nuclear Energy Institute in Frascati, Italy. A solution of thorium nitrate was placed in a special cell and subjected to high-voltage electrolysis. As has been found by several other investigators, the amount of thorium was reduced, as shown by both a reduction in radioactivity (12 percent reduction), and a chemical analysis (18 percent reduction) of all parts of the apparatus. The appearance of significant quantities of previously absent elements was also detected, with a few having abnormal isotopic ratios.

One of the few radioactive elements made by CANR methods is tritium, a beta-emitting isotope of hydrogen. One of the most carefully done studies of its production is being undertaken by Dr. Tom Claytor, of Los Alamos National Laboratory. After hearing Dr. Claytor describe his work, little doubt can remain in an open mind that this element is being produced by a nuclear reaction within his apparatus. Unfortunately, the amount of this isotope is small, and its production is still very difficult to reproduce. Nevertheless, Dr. Claytor is zeroing in on those alloys able to produce with increased success.



TWO STUDIES OF HELIUM PRODUCTION DURING EXCESS ENERGY PRODUCTION

Compared here are data for experiments of Bush and Lagowski 1996 (solid circles) and Miles et al. 1996 (open circles and squares). Energy was produced over several hours while the generated gases flushed the system. The number of helium atoms produced per second were calculated based on the helium concentration in the flowing mixture of D_2 and O_2.

Helium is another nuclear product which is being seen by an increasing number of scientists. Dr. Melvin Miles, of the Naval Air Warfare Center, and Prof. Benjamin Bush, of the University of Texas, described their very careful studies of helium production during heat generation, using Pons-Fleischmann type cells. The two independent studies both show that helium is being produced by a reaction that is consistent with the quantity of energy expected if d-d fusion were occurring. In spite of several obvious rejections offered by skeptics, the growing amount of careful work is tilting the jury in favor of a nuclear explanation for the observed heat, when deuterium is used.

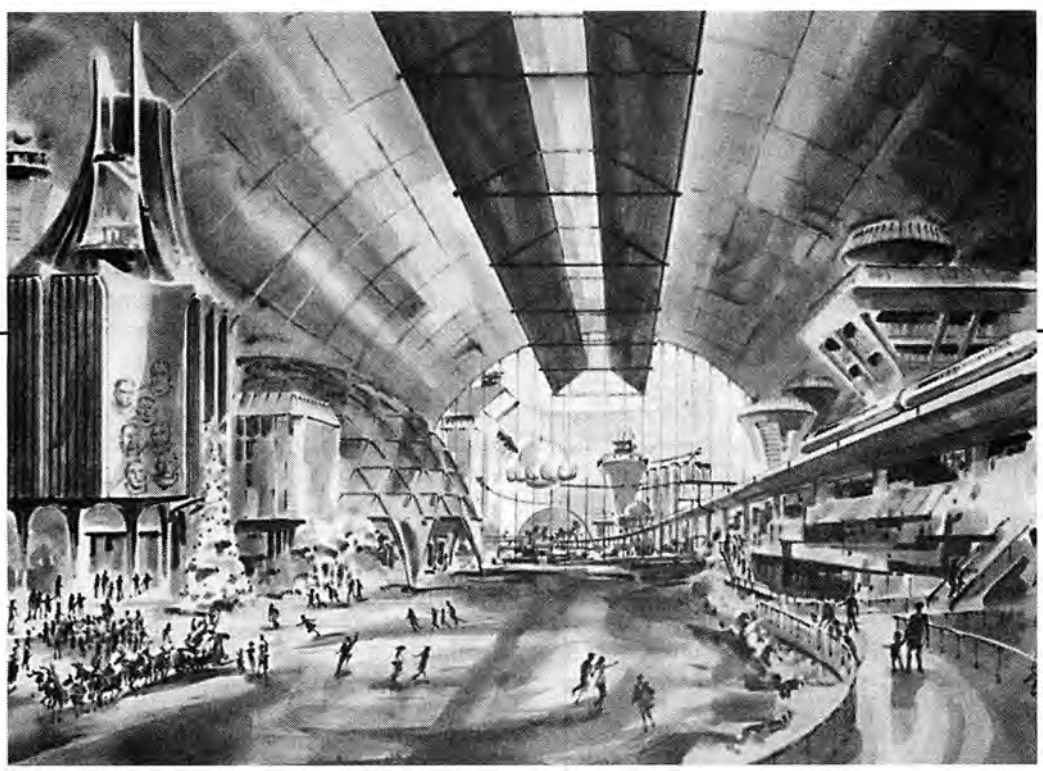
In addition to continued emphasis on the successful techniques, the presentations included results from basic chemistry and physics studies, attempts at an explanation, and more trial-and-error explorations of new methods. Unfortunately, all of these efforts, while essential to an eventual understanding of the phenomenon, are too underdeveloped to have an immediate effect on the skeptical climate or to produce insights needed to amplify the effect. Until overcome, this skeptical attitude will continue to influence denial of funding and patents and, thereby, hamper a normal development which promises great benefits to the general public.

Edmund Storms retired in October 1991 from Los Alamos National Laboratory in New Mexico, where he had worked for 32 years. His research there was on the SP100 space nuclear program and space nuclear propulsion systems.

Krafft Ehricke's Moon: A Lush Oasis of Life

by Marsha Freeman

Only a grand vision for lunar development will move space programs into the future.



"Like the giant cathedrals of the Middle Ages, Selenopolis will be the work of many generations."

—Krafft Ehricke

Christmas in Selenopolis in the year 2031, as envisioned by Krafft Ehricke. The Hall of the Astronauts (left) and the elevated monorail providing transport around the city (right) flank a traditional ice skating rink. The dome (rear left) provides storage for supplies, and houses the life support and climatizing equipment. The transparent dome in the center rear is the entrance to the tropical habitat sector of Selenopolis.

Since the end of the Apollo program in 1972, there has been great frustration expressed by planetary scientists, space mission designers, young children, and occasionally, even the Congress, at the lack of long-term goals for the U.S. space program. The overwhelming response by the American (and international) public to the movie *Apollo 13* three years ago, and to the recent series about Apollo, *From the*

Earth to the Moon, shown on the HBO television network, belies the oft-repeated mantra that the American public has "lost interest" in space.

Increasingly since the early 1970s, the notion that carrying out bold efforts in space is "too expensive," and that it drains resources from the terrestrial economy, has led to an approach by national space agencies to propose only the "cheapest" space missions, necessarily requiring that they be done quickly and, largely, with already available technology.

In fact, the reason we do not have a progression of increasingly complex space missions under way, in logical steps toward bold goals for the future, is *not* because what has been proposed is too expensive or pie-in-the sky—just the opposite. As civilization on this planet has become increasingly ruled by the self-destructive policies of post-industrial zero-growth, we have set our sights lower and lower. This has reached the level of absurdity, where the money spent by HBO to portray the Apollo missions, and to try to preserve that magnificent accomplishment for future humanity, cost more than the United States was willing to spend on the current Lunar Prospector mission, to actually *go* to the Moon!

As space visionary Krafft Ehricke restated throughout his life, space is not a place, nor a series of missions, nor line items in budgets. It represents the next step in the natural evolution of the human species. The goal of a lunar program, Ehricke stated, is not an outpost or a lunar base, but the building of a city on the Moon, which he called Selenopolis. Like cities on Earth, Selenopolis will embody the culture and accomplishments of civilization, accommodating millions of citizens who engage in scientific research, exploration, and recreation, while developing the industry and agriculture needed for self-sufficiency and interplanetary trade and commerce.

To express this understanding, Ehricke developed what he called "the extraterrestrial imperative." The reason mankind moves into space, he believed, was the same reason that life moved through past evolutionary stages—to grow by developing new capabilities. Extraterrestrial man will not even be the first species to take advantage of extraterrestrial resources, Ehricke said. The first instance of the use of astrogenic resources was the development of photosynthesis using water, carbon dioxide, and extraterrestrial solar radiation.

Life's "first Great Crisis on Earth," he explained, occurred when the limits of primitive chemosynthetic processes, mostly fermentation, were reached:

> But what seemed to be an absolute limit to growth was no limit to growth. It was the beginning of a series of evolutionary technological advances that led to more growth. Metabolic advances in the photoautotroph led to the chlorophyll molecule and photosynthesis.

This development led to the "magnificent negentropic creation of the biosphere, as life "gained control over the production of its basic staples of food and energy."

With man, further evolution will be planned and purposeful, based on his uniqueness. The human being, Ehricke wrote, has the seed of the next higher metabolic capability—thought:

> We all know what information metabolism has accomplished so far. It is the foundation of human civilization, including the industrial revolution that replaced slaves by machines. It is also the bridge to the cosmos. It can now enlarge our environmental base—not only for resources, but for growth in technology and, thereby, human existence.

For Krafft Ehricke, the next evolutionary step for mankind, into the cosmos, lies in the foundation of the philosophical organizing principles of his civilization. From the 1970s on, he increasingly recognized that the zero growth ideology must be overturned, before evolution into the cosmos would be possible.

> I must emphasize that technology is not the solution to our shortcomings. The solution is that we must grow and mature. But technology can make that easier. By contrast, a no-growth philosophy, which asks humans to live with less of everything, can regress us to the Middle Ages, because a dog-eat-dog fight is bound to break out under such conditions.

The purpose of space exploration for Krafft Ehricke was not to complete a series of interesting missions, or to simply *learn* more about the Universe surrounding us.

> Expanding into space needs to be understood and approached as world development, as a positive, peaceful, growth-oriented, macrosociological project whose goal is to ultimately release humanity from its present parasitic, embryonic bondage in the biospheric womb of one planet. This will demand immense human creativity, courage, and maturity.

At this time and place, to insist that this tired world does not have the resources, by which is meant money, to move human civilization into space, is nothing but a lie, through the worst fallacy of composition.

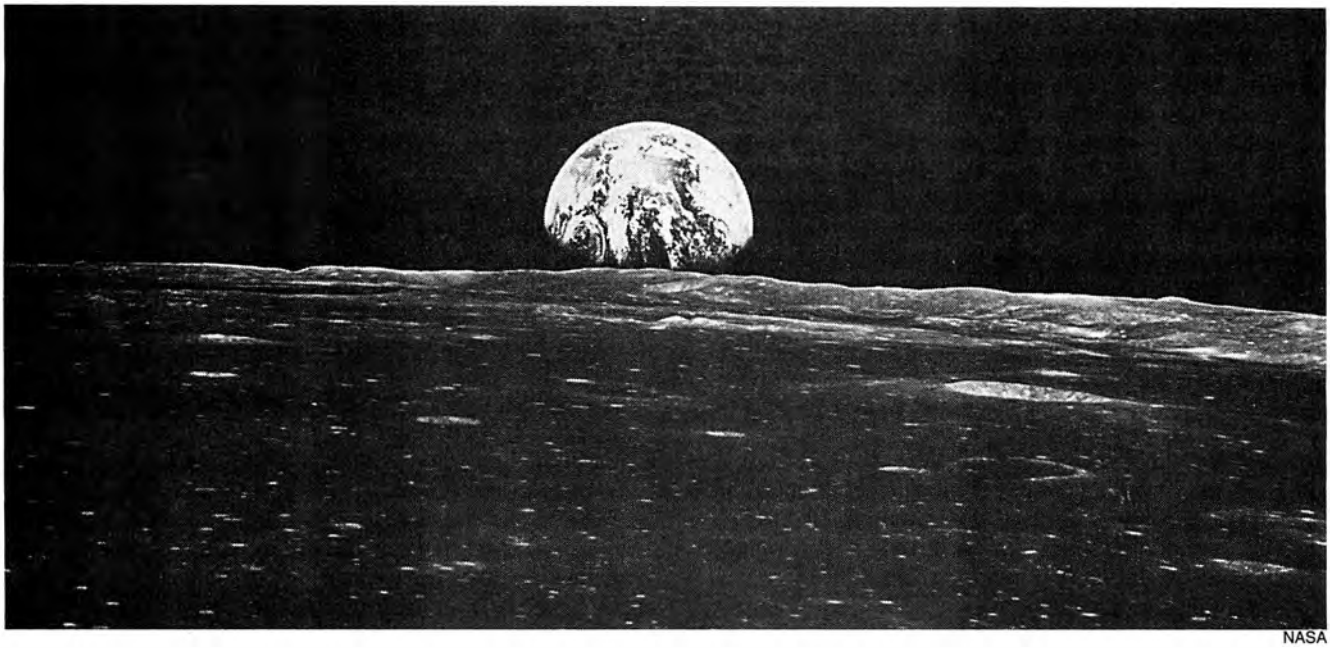
Were the sane governments of the world to dry out the *trillions* of dollars that daily whirl through financial markets, feeding a speculative bubble that is close to popping, it would quickly become obvious that there is no shortage of money; but there *is* a shortage of scientists, engineers, teachers, steel production, research laboratories, machine tools, and energy. These shortages we can correct through the simple direction of resources to meet the needs of the majority of the world's population today, by developing the capabilities to take them into space, tomorrow.

Why the Moon?

'It has been said, 'If God wanted man to fly, He would have given man wings.' Today we can say, 'If God wanted man to become a spacefaring species, He would have given man a moon.'"

—Krafft Ehricke

Over the past few years, stunning new discoveries about the planet Mars, both from pieces of it that have found their way to Earth and arrived here as meteorites, and from the Pathfinder mission that did *in situ* exploration, have led to proposals for manic, harebrained schemes to send manned missions to



NASA

The Earth is part of a two-planet system. This photo taken by the crew of Apollo 11, July 16, 1969, shows the Earth rising, as seen from the surface of the Moon.

Mars. Such programs to send people on years' long, high risk missions, without having done the required preliminary work, have no place in a world-historic effort to move human civilization into space.[1]

"We are fortunate to be part of a double planet system," Ehricke wrote, "with a nearby sister planet whose surface conditions, despite all their differences from ours, still bear closer resemblance to Earth than do any other accessible surfaces in this Solar System."

In 1957, after having participated in the earliest steps into space, in pre-war German amateur rocket societies and the wartime rocket program at Peenemuende, Krafft Ehricke wrote an article outlining what he called the "Anthropology of Astronautics," in which he promulgated three fundamental laws:

> *First Law:* Nobody and nothing under the natural laws of this universe impose any limitations on man except man himself
>
> *Second Law:* Not only the Earth, but the entire solar system, and as much of the universe as he can reach under the laws of nature, are man's rightful field of activity
>
> *Third Law:* By expanding through the universe, man fulfills his destiny as an element of life, endowed with the power of reason and the wisdom of the moral law within himself.

A few years later, Ehricke had developed his concept of the Extraterrestrial Imperative, concluding that after the initial exploration, there should be three evolutionary phases of our expansion into space, guided by his three principles:

Space Industrialization: the capability of productive existence in the new environment

Space Urbanization: the capability of establishing large-scale settlements and extraterrestrial civilization, to the extent to which it can be underwritten by industrial and biotechnical productivity

Extraterrestrialization: a prolonged process of socio-psychological development and anthropological divergence, based on the integration and further evolution of the first two phases, manifesting itself in the physiological, anatomical, immunological, esthetic, and general cultural sectors." That is, the establishment of an entirely *new* civilization, which may bear more or less resemblance to the one that begat it.

After considering the various venues for operations in space, Ehricke concluded that the extraterrestrial imperative requires the movement of civilization to Earth's sister planet:

> In the past, human growth could unfold in a monoglobal framework. In the future, human civilization needs to be polyglobal. The Moon is the first step. It is a seventh continent, almost as large as the Americas. It is large enough to support a civilization. It alone offers the opportunity to create a strong exo-industrial economy based on highly advanced nuclear, cybernetic, and material processing technologies, ultimately turning large parts of the once-barren lunar surface into a lush oasis of life, capable eventually of exporting even foodstuffs to orbiting installations, if not to Earth.
>
> The Moon is the logical proving ground for subsequent industrial developments and settlements elsewhere. Only 2 to 3 flight days away, it allows us to develop at our very doorstep the experience we need to operate successfully and cost-effectively in more distant regions. No other celestial body and no orbiting space station can more effectively permit development of the habitats, material extraction and processing methods, and in essence, all the science, technology, and sociology required for a responsible approach to extraterrestrial operations.

For Krafft Ehricke, the development of the Moon represents the proof-of-concept for the extraterrestrial imperative, because the Moon cannot support life without the intervention of man:

> For Selenians, creation will be the major trade. The human being and its technosphere arrive first and then create a biosphere. This kind of creation will require an approach that is rational and effective without precedent. . . . Whatever the details of the human relationships may be, Selenians will be space "amphibians" travelling with ease between surface and orbital gravitites and later, in the gravities of Mars, as well as on the moons of Jupiter or Saturn.
>
> The Moon is the touchstone of the human future. Instead of searching for and speculating about life elsewhere, we will put it there. Forthwith, civilization will be three-dimensional, and life will be polyglobal. Living at the ethereal shores of heliocentric space, the Selenians will be the Cosmopolynesians of the solar system, navigating between worlds.

A Lunar Investment Strategy

"Lunar development must be rooted in a viable lunar economy, which I call 'seleneconomy.'"

—Krafft Ehricke

The unmanned scouting and prospecting missions to the Moon, and the basic infrastructure needed to transport men into space, are the responsibility of national governments. Just as the U.S. federal government sponsored explorations missions, like that of Lewis and Clark, and directed the building of the railroads across the nation to enable the movement of civilization from one coast to the other, a national effort is required, to provide access to space and missions to survey the future terrain.

Assuming that these very first steps will have been completed, Krafft Ehricke proposed that a lunar development strategy should "maximize investment returns, minimize return times, and keep investment sizes manageable, so that venture capital and private investment can be attracted as rapidly as possible." The goal is to create a nearly self-sufficient lunar economy, which has a relationship to Earth similar to that of individual nations on Earth to each other, based on trade and sovereignty.

To reach that goal, he proposed that the general rule be that investments by private companies, in the lunar economy, be "independence-oriented." Primary areas of investment should include the use of nuclear energy, for power supply and industrial processing, rather than for transportation; the reduction of the use of terrestrial propellant through the production of lunar oxygen (LULOX), and use of LULOX depots on the Moon and in relevant orbits, especially geosynchronous and near-Earth orbits; and the extensive use of lunar materials for construction, shielding, growth of food plants, and for other purposes.

"In summary,"Ehricke stated:

> maximum value generation capability and flexibility should be achieved with minimum initial expenditures and lead time. Only on this basis can lunar industry be developed early, effectively, and in a financially responsible manner. And only rising productivity and sustained economic growth can sustain an ever-increasing lunar population and the development of high Selenian living standards.

Industrial enterprises on the Moon will create mining and manufacturing facilities to produce semi-finished and finished products made from the iron, titanium, magnesium, sodium, silicon, and other raw materials of the Moon. These will be fashioned into all manner of products from sheet metal, bars, wires, glasses, and ceramics, to silicon chips. From these semi-finished products will come products such as entire structures of solar cells made of various metals and alloys for lunar and

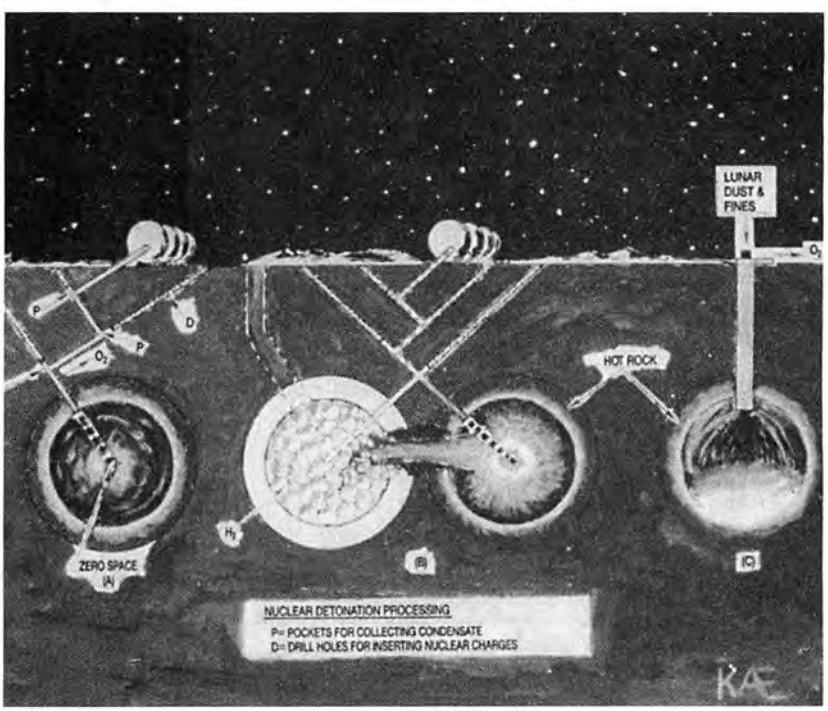


Figure 1
THREE TECHNIQUES FOR UNDERGROUND MINING
Krafft Ehricke worked out in exquisite detail many of the technologies that living and working in a lunar environment would require. Here he presents techniques for underground mining, using small nuclear detonations.

Source: Krafft Ehricke

orbital installations; heat shields and insulation materials, as well as radiation shielding materials for space stations; propellant containers for entire orbiting facilities, such as space station and factory modules, and liquid lunar oxygen depots; large portions of cislunar and interplanetary spacecraft; and so on.

Ehricke envisioned lunar operations, as they develop, moving toward a *total* industrial system. The key is to progressively minimize non-selenogenic imports from Earth. As these new extraterrestrial industries move toward self-sufficiency, they will support orbiting and terrestrial industries with oxygen for transportation, and an increasing variety of materials, products, and services, which will balance their imports from Earth. He saw four primary markets for lunar industrial product:

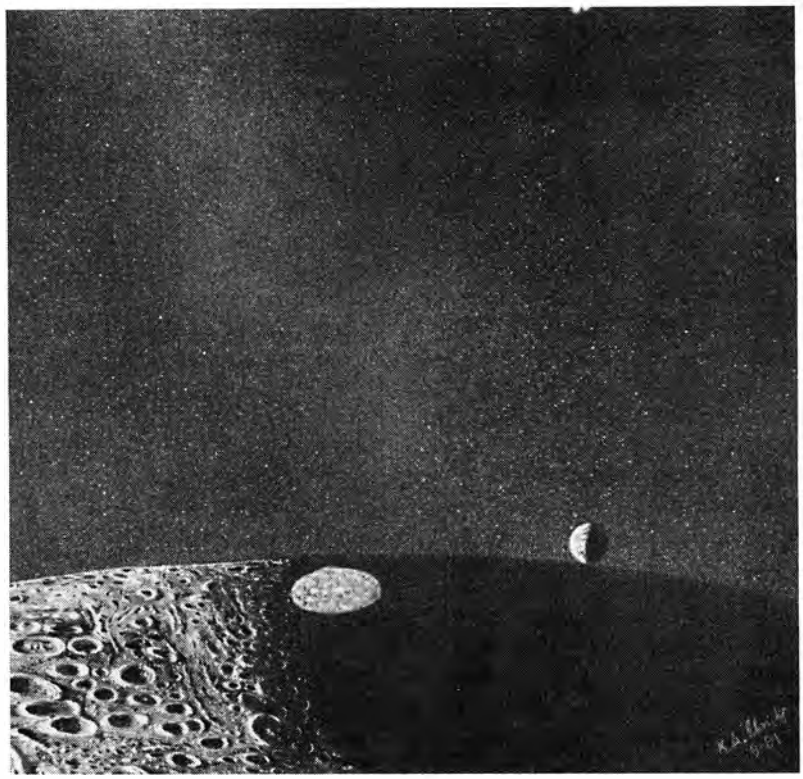
First, would be the lunar surface itself, where there will be a domestic demand for lunar industrial and habitational development. Also, there will be services performed on the lunar surface for the benefit of the "folks back home" on Earth, such as "science and technology experiments for terrestrial customers, new forms of entertainment for terrestrial television viewers, and eventually tourism and retirement environments for Terrestrians."

In 1984, Ehricke envisioned that by the year 2000, Geosynchronous orbit "may well hold over 1,000 satellites that will be virtually indispensible socio-economically," primarily for communications. "This market will demand spacecraft servicing; replacement parts; new components, and partial or entirely new satellites; salvaging and recycling of inoperative systems, sections, components, and elements," which could eventually be supplied from lunar industrial facilities. In addition, LULOX filling stations might be established to reduce the cost of supply deliveries needed from Earth.

Third, Ehricke proposed that Near-Earth orbit (NEO) microgravity manufacturing facilities will be likely buyers of lunar raw materials, capital equipment, entire production facilities, oxygen (not only for air but also for water), and eventually even some basic dehydrated foodstuffs.

And finally, the Earth itself, Ehricke wrote,

> will be a major market for lunar raw materials, semi-finished products, and space-made components in larger quantities and involving larger masses than could be handled economically if the raw material should first have to be supplied from Earth in Near Earth Orbit manufacturing facilities. These lunar imports will sustain industries and create new job markets on Earth.



Krafft Ehricke

Reflecting mirrors, called Lunetta by Ehricke, can be seen at the top right of this 1981 painting, as they orbit the Moon. With the Earth just at the horizon, Lunetta provides areas of light near the terminator on the Moon, to allow for mining and other operations during the two-week lunar night.

The Five Stages of Lunar Development

"Each of the five lunar development stages include three main sectors: (a) the technosphere (research, technology, industry); (b) the biosphere (plant/animal, life, food production, general plant growth, selenbiosphere); and (c) the sociosphere (habitats, living and working spaces, society, economy, politics, and culture)."

—Krafft Ehricke

Stage 1. In 1984, Ehricke proposed that this stage could be accomplished in this century. It involves the synoptic prospecting of the Moon to detect metallogenic or mineralogenic provinces, and obtain further advanced information needed for industrial site selection. He suggested that simplified Surveyor-type landers, which were used in the 1960s unmanned Apollo precursor missions, could be used, and at least one lunar polar orbiter.

The first development stage would also include the development and deployment of a Lunetta reflector orbiter, or space mirror, "to illuminate the perpetually shadowed places at high latitudes and the polar regions to permit photography, cartography, and the possible identification of polar ice deposits, if any."

Stage 2. This involves further work toward surface base site selection and operations training for personnel, prior to lunar base build-up.

A Circumlunar Space Station (CLSS) is established in about a 100-km equatorial lunar orbit and makes use of a Moon Ferry for limited manned surface missions. It serves as a habitat, operations and training center, and laboratory for engineering, biological, and medical purposes. Such a facility in lunar orbit will support experimental research with much larger quantities of lunar materials than could be economically delivered from the Moon to Earth, Ehricke explains. Most

Krafft Ehricke

Krafft Ehricke's depiction of a first-generation laboratory/habitation module is made up of hardware that would be "mailed" from Earth. The inverse converging shape maximizes shielding against radiation, optimizes temperature control in equatorial regions, and even serves as an umbrella to provide shade.

lunar materials will be brought from the surface to the CLSS by automated returners. The data obtained should lead, about halfway through Stage 2, to selection of the appropriate surface base site.

Experience in this stage will also provide medical and behavioral profiles of the personnel, who will be spending time in the two worlds of the lunar surface and the orbiting space station.

This Development Stage includes the establishment of sophisticated, automated laboratories and pilot facilities on the surface. Modules are "mailed" from Earth to the selected base site and, using the Moon Ferry, CLSS personnel descend to the surface to set up, start, and maintain the systems. These pilot facilities could include the first small-scale automated lunar oxygen extraction plant, providing gaseous oxygen fuel for the Moon Ferry and CLSS. Other modules placed on the Moon during Stage 2 can permit personnel to stay on the surface for weeks at a time.

Stage 3. This marks the beginning operation of lunar industry.

A first-generation nuclear-powered Central Lunar Processing Complex (CLPC), which Ehricke named "Cynthia," is established in a region where there are favorable conditions for a transportation node, and for finding valuable raw materials nearby. Cynthia's first job will be the large-scale production of oxygen, and then, other materials. Construction skills, learned from the previous stages, will be needed, including cold-welding, cutting of lunar rocks, producing lunar bricks and possibly cement with lunar sulfur as a binder (instead of water), and compacting lunar fines (powdery to coarse sandy material) into building blocks for lunar igloos, or ligloos. These ligloos will have sprayed airtight inner liners and airlocks—providing shirtsleeve shelters, workshops, and "greenhouses" for growing food plants.

The first-generation lunar crews can schedule Cynthia for production runs of oxygen, silicon, aluminum, iron, glasses, and other materials, depending upon what is needed. From these raw materials, Cynthia can progress to powder metallurgy, vapor phase metallurgy, production of solar cells, computer parts, and eventually space habitat structures, communication platform structures, antennae, service satellite parts, reflector structures, and much more.

During this stage, the orbiting space station of Development Stage 2 grows into a staging base, training second-generation selenauts and expanding into a zero-g factory.

Stage Four. This is characterized by the expansion of industrial production and services. Industrial diversification grows beyond extraction and semi-finished products to finished products and assemblies: As Ehricke envisioned it,

> Strategic economic positions must be attained for supplying orbital and terrestrial markets, yielding a high gross lunar product that not only builds a positive balance of trade, but also builds the infrastructure and establishes credit-worthiness for continuing expansion.

To broaden market response capability, Cynthia is augmented by feeder stations, in sometimes distant provinces identified during Stage 2 as having an abundance of certain valuable raw materials. Today, with the indications of the presence of water ice at the lunar poles, such would be candidate sites for such Feeder Stations.

The Feeder Stations are highly automated and basically simple. Most are unoccupied or intermittently occupied. They are remotely controlled, and Ehricke suggests that they be operated from the central complex by laser communication link via a novel series of communication relays.

> Materials collected at the Feeder Stations can be transported to Cynthia by various methods, depending on distance. Relatively close Feeder Stations, say 120 miles away, can send cargo by electric cars. The most important Feeder Stations can eventually deliver goods via high-speed electromagnetic trains. Meanwhile, distant Feeder Stations can hurl cargo ballistically to receiver craters near Cynthia with great accuracy, thanks to low lunar gravity and high vacuum.

Stage 4 also includes installation of fusion power plants, and the initial buildup of a solar reflector swarm, termed, "Soletta," placed in L-1. Eventually, Soletta will reach the size of 120,000 sq km, illuminating an area of 200,000 sq km during the lunar night, for agricultural and biospheric purposes (creating Novaterra). Biospheric Novaterra and technospheric Cynthia become the pillars on which sociospheric Selenopolis and lunar civilization rest.

Building the Technosphere

"Selenopolis cannot be built with yesterday's technology."
—Krafft Ehricke

From the first stages of lunar development, energy will be the critical element for progress. Electrical and directed energy will have to substitute for the often water-based chemical processing methods commonly used on Earth. The separation and refining of the Moon's raw materials, starting with oxygen, will involve developing adequate processing heat, at the lowest possible cost.

The hierarchy of possible energy sources for raw material processing, as outlined by Ehricke are, in order of increasing temperature: the high-temperature reactor (HTR), with reactor-cooling gas outlet temperatures of 900 to 950°C; nuclear-electric arcs (less suitable for quantity production); solar concentrator-heater ovens, for temperatures up to several thousand degrees and low mass requirement (inoperative, of course, during the 354-hour-long lunar night); underground atomic ovens stoked by small fission or fusion detonations; and the plasma from a fusion reactor, once this technology is developed. For early application and high-mass flow, day and night, the HTR and underground atomic ovens are the most effective methods, in addition to solar heating during the day.

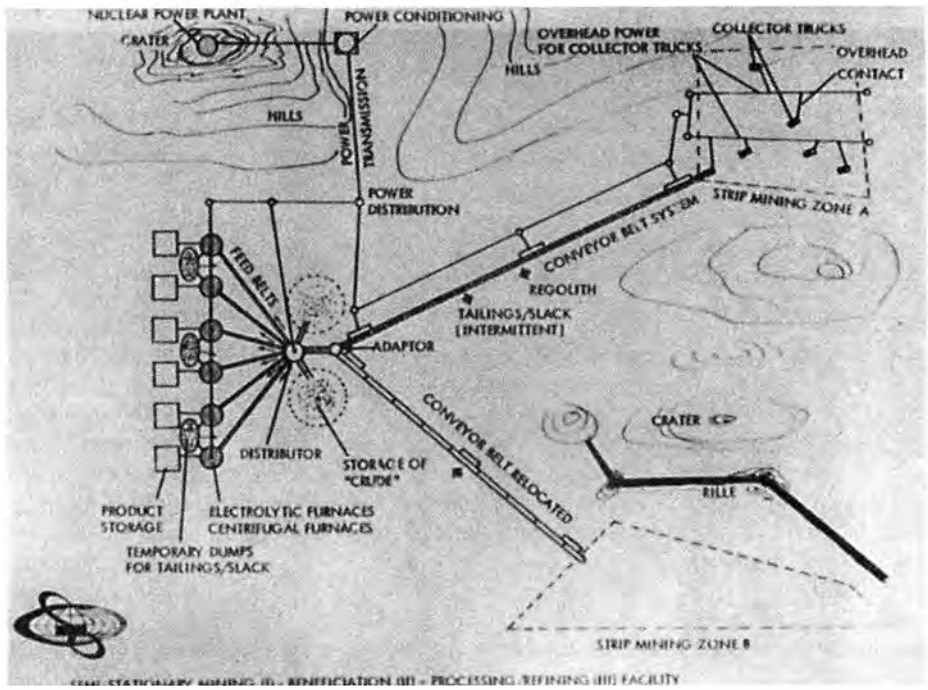


Figure 2
MOON MINING AND PROCESSING

During Development Stage 3, the first strip mining, beneficiation, processing, and refining facility will be established, as part of the Central Lunar Processing Complex, called, Cynthia. Material mined on the surface is sorted and fed into furnaces. Raw materials to be refined are removed, to be processed for transport to circumlunar orbit and further processing at zero gravity. Some can be exported to customers in Earth orbits, and on the Earth.

Source: Krafft Ehricke

As we move forward in time, through the Development Stages toward the creation of Selenopolis, new, more intensive, forms of energy become necessary. "For economy, and because of the long lunar night, fusion energy is as fundamental and as indispensible to the Selenosphere as the Sun's energy is for the terrestrial biosphere." The fusing of light nuclei in a reactor, like that which takes place in stars, yields energy orders of magnitude greater in energy flux density than the nuclear fission process, and the direct use of the fusion fuel plasma allows the direct reduction and separation of any and all materials.

Unlike most who have designed transportation systems for lunar development programs, Krafft Ehricke insisted that the approach should not be to use the same vehicles for a wide variety of functions, because it appears to be "cheaper" than developing new vehicles, but to develop "a novel class of vehicles, facilities, and techniques that use the unique lunar and cislunar environments to advantage." As the payload requirements for the developing lunar civilization change, so will the requirements for the transportation system.

In Development Stages 1 and 2, Ehricke proposes, the payloads required for lunar prospecting, establishment of the Circumlunar Space Station, and pilot surface facilities can be delivered to the Moon and Cislunar Orbit by combinations of the Space Shuttle, a Shuttle derivative to carry more cargo (the Heavy-Lift Launch Vehicle), and the liquid-hydrogen Centaur upper stage used today, which was designed by Ehricke. The Centaur could function as an orbital transfer vehicle, to take the payload from Earth orbit to lunar orbit.

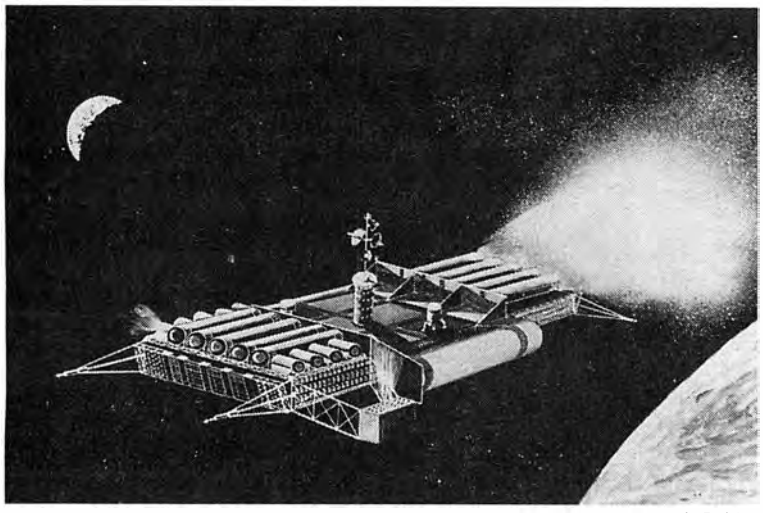
A City on the Moon

"For those coming generations who are born on the Moon and who are not transfixed by the beauties of Earth, and for those who remain on the Moon except for vacation or business trips to Earth, there will be no place in geolunar space more beautiful, vital, or abundant with the future than the Moon and the selenosphere created on it."

—Krafft Ehricke

Stage 5. This establishes the city, Selenopolis, and the selenosphere—"a fully developed lunar world with a large population underwritten by industry." Ehricke cautions that

> this stage is contingent upon a strong economic foundation, a very high degree of self-sufficiency, particularly in food production, and a powerful fusion energy base. Initially, it will require more massive imports from Earth. But its expansion should be commensurate with economic growth and the ability to sustain



Krafft Ehricke

Ehricke's cislunar superfreighter would use lunar oxygen and aluminum, to travel between the Moon and Earth, carrying lunar "bounty," and supplies from the mother planet.

corresponding population increases, thereby financing its evolution to a high degree with lunar capital.

At this point, with a growing industrial economy and independent economic and financial base, "we move into the twilight zone between economics and politics," Ehricke states. There will be the "onset of the social and cultural extraterrestrialization process," where "the issue will arise concerning the extent, in Development Stage 5, of financing and controls by terrestrial institutional power."

In this stage, there is a state "in which trade relations with Earth are based on rough commercial equality. This means mutually complementary value generation, where lunar civilization is not in a receiver position vis-à-vis Earth. The resulting high level of fiscal and economic self-determination, and the attraction of terrestrial investment capital," cannot help but encourage political independence. Therefore, Ehricke says, the questions posed in Development Stage 5 will include:

> Will this be a colony of Earth, part of the common heritage of terrestrial mankind? Or will it be an independent political entity with Selenians in control of their own world? On a foundation of fusion power, the vast potential of the lunar economy renders the latter alternative possible and hence likely.

While the early lunar habitats "are envisioned as a series of small units hugging the inside walls of a crater, Selenopolis—the city-state of lunar civilization and the lunar biosphere—will be a network of enclosures gradually expanding to cover many square miles of the lunar surface, and some parts of the subsurface." Ehricke envisions a city that is comprised of several sections, each several miles long.

Selenopolis embodies urban, rural, agricultural, industrial, and resort areas, mirroring the variety we have created for ourselves on Earth. Each section has a different Earth-like climate and season, and normal atmospheric conditions for Earth are maintained. In the beginning, simulated Earth climates will include continental, dry subtropical, and semi-arid, with Earth-like climatic cycles, where applicable.

> Other sections will have climates that are adjusted to their special agricultural functions in order to maximize plant growth (measured as yield per unit area and number of crops per annum). This will be accomplished primarily through CO_2 enrichment of the atmosphere, and by temperature, humidity, and suitable irradiation cycles, all coordinated to achieve the optimum combination.

Selenopolis will not be all work. Ehricke envisions resort areas, that can include a winter section with snow, a subsurface lake for boating, and a "sunbelt" with "lunar desert" views from a clubhouse that also overlooks the Alan B. Shepard low-gravity golf course. Selenians may also use the Krafft A. Ehricke rotating swimming pool.

The interiors of the city are illuminated by natural sunlight reflected through the ceiling by a mirror system. But since a lunar day is 14 Earth-days long, and there is no change of season or beautiful sunsets, "some of the mirrors are colored to provide the same time changes and sky colors experienced on Earth from morning to night and from season to season."

Selenians will not be hostage to the biological environmental niches in their city.

> In comfortable space vehicles, or in transport vehicles with interior shirtsleeve environments, they can tour the coasts of mare, the mountains, the cliffs of the southern highlands, the province of large craters stretching from the eastern coast of the Mare Numium to the South Pole, and more.
>
> With the establishment of Selenopolis, the development of lunar habitation reaches its conclusion, in the sense that a new environmental niche—a lunar biosphere honeycombed with ecological niches—has been created. But Selenopolis is open-ended, growing with its population and advancing technologies. In principle, the overall complex could eventually house many hundred million people. Such a large complex is never completed, just as development of a continent is never completed.

Krafft Ehricke's vision of Selenopolis—in words and in graphics and painting— is the appropriate goal for any and all lunar exploration programs. We must evaluate how far we are advancing with that as our measuring stick.

Where Are We Now?

Transportation Systems. Although since the 1980s, there has been no progress in developing the U.S. heavy-lift launch vehicle for interplanetary cargo that Krafft Ehricke envisioned, the dramatic political changes in the former Soviet Union have created the possibility, if not the necessity, for the international community to make use of the capabilities that now lie dormant there.

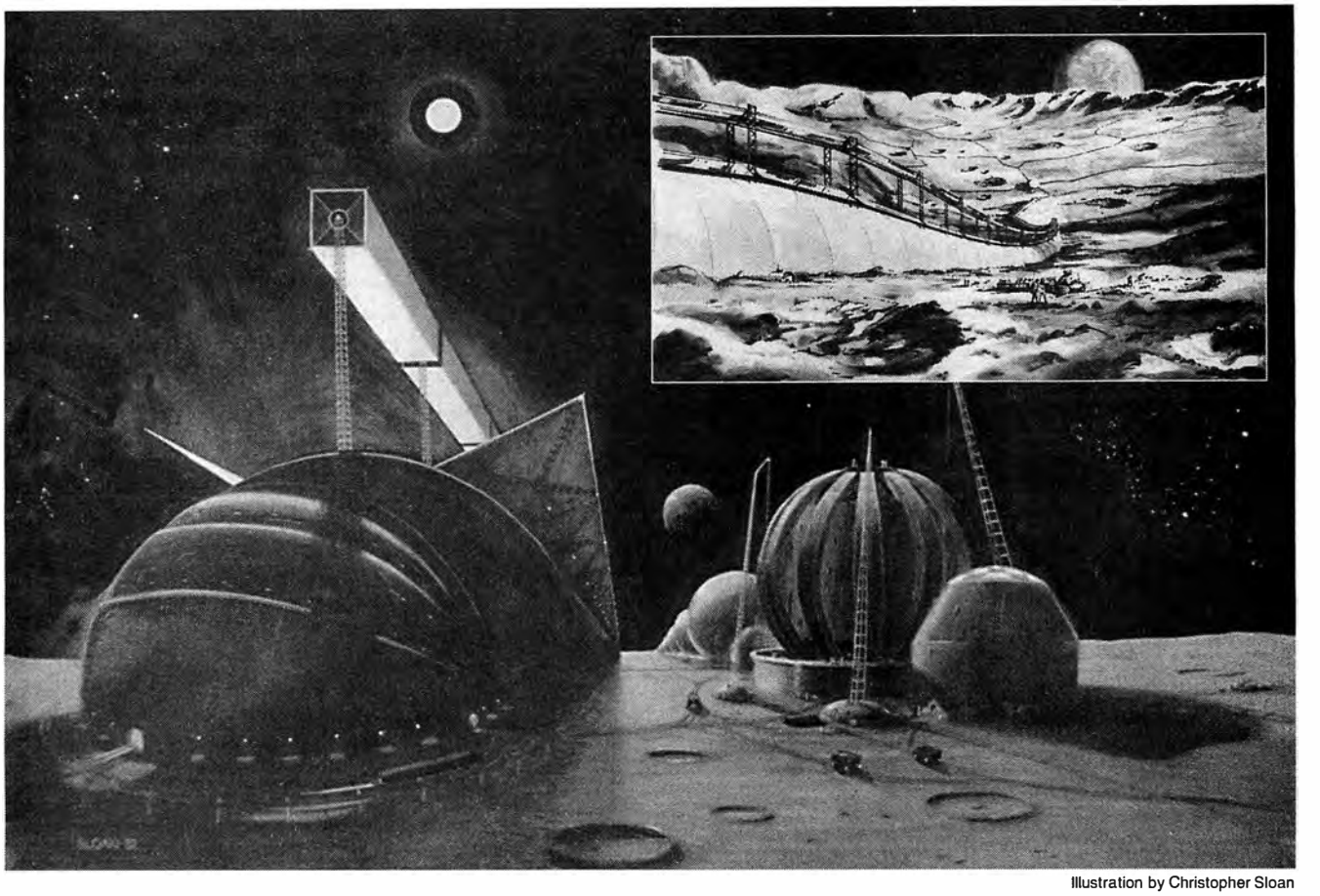


Illustration by Christopher Sloan

Selenopolis will be a lunar city housing tens of thousands of selenarians, and the kernel from which will grow other cities, and an entirely new civilization. Here, fusion power plants are under construction to the right of the city, and an elevated transport system connects the city to other points on the Moon. Inset: Ehricke's illustration of the exterior of Selenopolis shows the transport system, winding its way past an industrial mining project, with the Earth at the horizon.

In 1992, J. Lassmann of the Institute of Aeronautics and Astronautics at the University of Berlin, presented a paper at the World Space Congress on the possible use of the Russian Energia rocket, with an energetic third stage for lunar transport. His estimate was that a cargo version of the Energia could land 15 tons of payload on the Moon for about $25,000 per kg, or about half the cost of a comparable Apollo-era Saturn V mission.

Lassmann proposed an integrated staging scenario, including an orbital filling station in Low Earth Orbit and tankers that would travel between the Earth and the Moon, carrying lunar oxygen. He warned then that "This historical opportunity for international cooperation will last only for a few years. Two complete Energia launchers are stored and have to be launched within the next 3 to 5 years. . . . Very soon tools, workers, and engineers will be no longer available at Energia's production and launch facilities in the Russian Federation."

In Development Stage 2, Ehricke assumes that the Space Shuttle capability will be increased to that of the Heavy-Lift Launch Vehicle, and Centaur II to evolve to a cluster of rockets which would function as the drive for a large, first-generation Geolunar Transport, to establish the Circumlunar Space Station. Development Stage 2 would also establish the requirements for two new transportation systems—a Moon Ferry to go from lunar orbit to the surface of the Moon, and a "highly cost-effective" nuclear-electric geolunar freighter. Although the electric propulsion, which is very efficient, has low thrust and does not accelerate quickly, we would want the cargo they would haul to travel cheaply, not necessarily quickly, like the barges on our rivers.

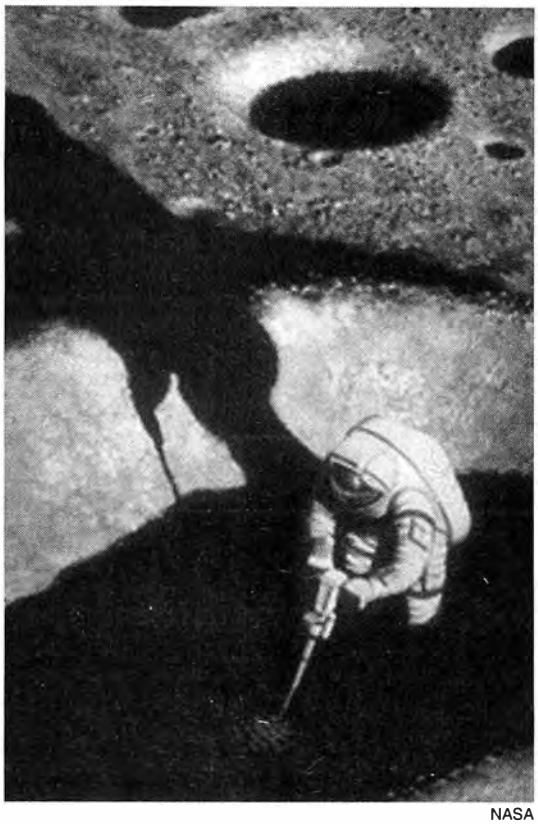
Nuclear Energy for Space. No progress can be reported on the critical work that is needed to design, build, and test an updated nuclear electric generator for space applications either for lunar electrical power or for Ehricke's cislunar freighter. Under the rubric of NASA's current "faster, better, cheaper," there is little room for the development of complex, while vital, new technologies.

In a report by the National Research Council released earlier this year, "Space Technology for the New Century," a list of enabling technologies for space exploration that are *not* under development is indicated. One of these, that had been under development as far back as the 1960s, was space nuclear power. The Committee that prepared the report pointed out that eight years ago, the National Research Council had stated that "nuclear power eventually will be essential for lunar and Mars bases," yet nothing is being done.

While the Committee acknowledges that nuclear power may be "unpopular," it points out that "if NASA does not in-

vest now in the long-term Research and Technology that could lead to future high-efficiency, safer, nuclear power sources, future mission planners and spacecraft designers will be deprived of potentially valuable design options that could improve safety and performance and reduce the costs of future space activities."

Fusion for Selenopolis. Although in the 1980s, Krafft Ehricke reported on the advantages of using advanced fusion fuel cycles, such as the rare isotope, helium-3, he assumes it will have to be bred on the Moon, from lithium imported from Earth. As early as 1970, Apollo samples were known to contain helium-3, deposited on the Moon over eons, from the solar wind, but a new look, years later, at the data, the samples, and their potential, by fusion scientist Gerald Kulcinski and Harrison Schmitt, the Apollo 17 astronaut and geologist, led to a detailed proposal for mining this precious energy resource for export to Earth.



NASA

Mining on the Moon, whether for minerals or helium-3, will be automated on a commercial scale. Here a depiction of a prospector, taking samples inside a crater to determine if there are unusual concentrations of specific raw materials.

Their studies indicate that helium could be recovered from the lunar soil by heating, and then cryogenic distillation could be used to separate the helium-3 from the more abundant helium-4. If the first fusion power plant fueled with helium-3 came on line in the year 2015, Kulcinski and colleagues estimate, demand for the fuel to meet U.S. energy needs could be one ton per year by 2030.

But, they point out, to process enough lunar soil to obtain that ton of helium-3, multiple tons of other, very precious gases, such as hydrogen, would be released. In addition, mining soil just about anywhere on the surface of the Moon would yield, via extraction, 3,300 tons of water for each ton of helium-3. Kulcinski and Schmitt have recently pointed out that whether or not there is water ice at the lunar poles (which they question), adequate supplies of water can be "mined" from the lunar soil.

However, the world is little closer to developing a fusion reactor today than it was in 1984, when Krafft Ehricke last wrote about it. The same inability of societies today to plan and execute long-range plans in space is reflected in the slashed research and engineering development budgets for fusion.

Producing Lunar Oxygen. In Development Stage 3, a larger Geolunar chemical Transport-II is needed, along with a LULOX filling station in Cislunar Orbit. Ehricke continually stresses that transport costs are greatly lowered by having lunar oxygen available in lunar and Earth orbit to fuel the transport vehicles. Bringing the oxygen to space from the shallow gravity well of the Moon, rather than from the much steeper gravity well of the Earth, corresponds to a specific impulse of 12,400 to 15,200 seconds, in terms of the efficiency of the use of the fuel, Ehricke calculates, which could otherwise only be attained by a very advanced nuclear propulsion system.

Because the production of oxygen from the lunar surface is widely recognized as a crucial economic "enabling" capability for lunar transportation systems and industrial development, research in this area has moved forward, at least on a small scale.

The Shimizu Corporation, one of Japan's largest construction companies, was founded in Japan in 1804, and began research and development in space technology in 1984. Shimizu scientists and engineers are doing research into lunar soil reactivity, using Apollo samples from NASA, experiments with lunar soil simulant, and technology development experiments for raw materials processing and construction.

Working with McDonnell Douglas Space Systems Company in the United States, Shimizu has developed a conceptual design for a lunar base. The goal is for the "maximum use of available space resources to support exploration missions directly, and to push base life support toward self-sufficiency." In this step along the way to Krafft Ehricke's Selenopolis, they envision a 15-person crew, closed (self-replenishing) plant and human life support systems, a Mars test facility, a science laboratory, and telescopes.

In a joint paper presented in 1992 at the World Space Congress in Washington, Shimizu and McDonnell Douglas engineers evaluated a method Shimizu has developed for the hydrogen reduction of ilmenite ($FeTiO_3$) that is found on the Moon. The process of passing hydrogen through the ilmenite produces water, which can then be used as the feedstock for the lunar oxygen needed for fuel. Working with Carbotek, Inc. since 1991, Shimizu has done tests aboard a NASA KC-135 aircraft. By making parabolic dives, the aircraft can produce tens of seconds of microgravity, enabling a fluidized bed reactor to process lunar soil, at simulated lunar gravity.

In an *Ad Astra* article (Nov.-Dec. 1996), Carl Allen from Lockheed-Martin reports on his studies of the different methods for extracting oxygen from lunar rock and soil that have been proposed over the past 20 years. Most researched is the hydrogen reduction of iron oxide, which Shimizu is also studying. The theoretical oxygen yield is 10.5 percent by weight, Allen reports.

NASA

Lunar oxygen will be the Moon's first commercial product. It will dramatically lower the cost of transportation, and can be used to attract investment. Here, a tele-operated lunar oxygen plant is in operation, having received lunar soil from automated surface vehicles, for the extraction, liquefaction, and storage of the oxygen.

A metric ton of pure ilminite would produce 105 kg of oxygen, and a cubic meter of ilminite has a mass of almost five metric tons. Thus, a pickup truck load of this mineral could supply enough oxygen to launch a rocket, he concludes.

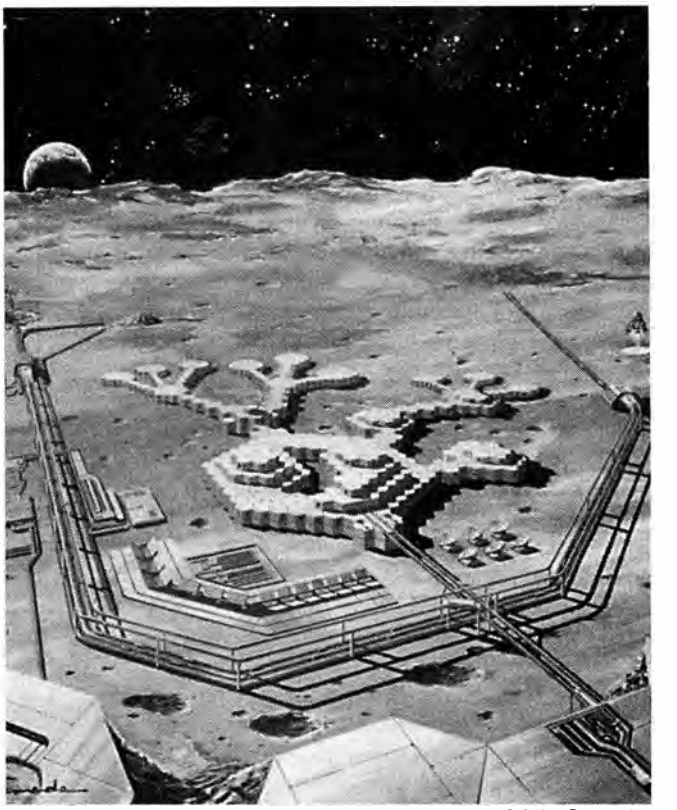
A group at NASA's Johnson Space Center, Allen reports, is looking at oxygen production from the soil or regolith of the Moon. "We have completed hydrogen reduction experiments on 17 different lunar soils." The oxygen yield was strongly correlated to each sample's iron abundance. Although yield was only as high as 3.6 percent by weight, "these experiments demonstrated that some amount of oxygen can be extracted from the soil anywhere on the lunar surface," but prospecting for locations of high iron abundance will provide the best oxygen yield.

Selling lunar oxygen to the captains of passing ships in cislunar space will be a going concern, even in the early stages of industrial development.

A team of researchers at NASA's Marshall Space Flight Center's Space Sciences Laboratory has also been investigating methods for the mining and processing of in situ materials on the Moon. They are examining novel techniques for using available lunar resources for structural and life support applications.

Construction on the Moon. Some preliminary design and technology work has been done by Shimizu in developing construction technologies, its forte, for the building of lunar bases. Another joint paper presented by McDonnell Douglas and Shimizu in 1992, described the development of lunar concrete for construction and shielding. Most current designs for lunar habitats throw regolith, or soil, on top of the structure for shielding against radiation. "More advanced bases should consider radiation shielding as part of the design process," the paper states.

The disadvantage of using tons of regolith for shielding is that it requires increased structural support for the additional weight of the soil. The Shimizu concept is to use prefabricated lunar concrete modules that are in the form of hexagonal prisms, and can be designed with different interiors for habitation, research, or other functions. Typically, concrete is about 5 percent water. The oxygen for the water would be liberated from the regolith through Shimizu's hydrogen reduction process, which also yields iron, useful for reinforcement of the concrete. But the company's plan relied on importing the hydrogen from Earth, in order to produce water with the oxygen.



Shimizu Corporation

Concrete modules in hexagonal shapes, which can be closely packed, are Shimizu Corporation's design for lunar bases. The modules allow the lunar base to be extended in any direction, and provide shielding against radiation.

Whether or not there is ice on the Moon, Lunar Prospector has measured a three-fold increase in the concentration of hydrogen at the poles, as compared to the equatorial regions sampled by the Apollo astronauts. If there is water ice at the poles, concrete could be that much cheaper to manufacture. Even if there is just a higher concentration of hydrogen, and not ice, at some point it might be economically feasible to "mine" that hydrogen and transport it to the lunar base that is under construction.

The Next Small Steps—Japan

Of the world's spacefaring nations, the Japanese have put forward, and are trying to *implement,* the most far-reaching lunar exploration program. The activity in Japanese industry is substantial. Three of the largest Japanese construction firms have spent $40 million on lunar projects over the past decade, and Shimizu alone spent $3 million just in 1997, according to an article in *The Wall Street Journal* April 2, 1997.

In a cultural sense, the Japanese are at a stage in their lunar program similar to where the United States was in the early 1960s; they are embarking on a lunar exploration program and want to organize public support for the effort. In 1990, Japan sent its first spacecraft headed toward the Moon. The Muses-A spacecraft was sent on an engineering test mission not designed to make new scientific discoveries about the Moon, but to practice a lunar swing-by as a gravity assist maneuver for future planetary missions. The first lunar science mission from Japan is Lunar-A, which is scheduled for launch early next year. Japan will become only the third nation, after the United States and former Soviet Union, to launch a spacecraft to the Moon.

The leaders of the Japanese space program, in order to inform and engage the public in this new effort, have embarked on an educational outreach campaign, reminiscent of the public appearances at elementary schools in the 1960s by NASA official and space pioneer, Wernher von Braun.

As reported in the April 1998 newsletter of the National Space Development Agency of Japan (NASDA) on Feb. 28, a Lunar Exploration Symposium was held for children at the Tokyo Metropolitan College of Aeronautical Engineering to "promote children's understanding of the significance" of the Japan's future SELENE mission to the Moon. There were lectures, a demonstration of a lunar rover, and a quiz session by scientists. More than 300 youngsters participated. The high turnout, both of individual children and elementary school classes, according to NASDA, was due to the fact that the "Moon is the most familiar celestial body to the Japanese."

Institute of Space and Astronautical Science

Japan's Lunar-A mission to the Moon will shoot two penetrators into the lunar surface. These small devices will make measurements of lunar seismometry and thermal properties.

The upcoming Lunar-A mission was approved by the Space Activities Commission of Japan 1991. It was designed to include three small penetrators to be released from an orbiter, each 3.3 feet long, to begin Japan's scientific study of the Moon. The penetrators will measure lunar seismic waves and the heat radiating from the core to the surface. A similar deployment of penetrators was part of the Russian Mars '96 mission, which unfortunately did not succeed in leaving the orbit of the Earth.

Each penetrator aboard Lunar-A has a small active attitude control system, to point it perpendicular to the surface. The challenge is to ensure that the penetrators hurl themselves into the lunar soil at a steep angle. If they do not, it is likely they would be destroyed on impact, since they will hit the lunar surface with the equivalent force of 10,000 Earth gravities. Each penetrator is expected to dig between 1 to 2 meters into the soil, and the data from each penetrator will be transmitted to the orbiter. The sensitivity of the seismometer in the penetrator is many times better than that of the Apollo program.

In June 1997, the probe failed vibration tests, which pointed to a weakness in the system to separate the probe from the orbiter, so it is being redesigned. The launch has been delayed until early 1999, and even the forward-looking Japanese are not immune to budget pressures. In October 1997, at the annual meeting of the International Lunar Exploration working Group in Turin, the Japanese reported that the delay to a February 1999 launch has placed the project over budget, resulting in a reduction of the number of penetrators from three to two.

In 2003, the Japanese plan to launch SELENE—the Selenological and Engineering Explorer—to include the first lander on the Moon in more than 20 years. The original design was for an orbiter and a small lander, which would have separated from the mother ship and landed at the beginning of the mission. But in January 1997, lander development was suspended after cuts in the NASDA budget, by the Ministry of Finance. Last July, it was announced that the lander will be terminated, and the main spacecraft will land after a year orbiting the Moon. This has cut 9.9 billion yen from SELENE's total cost of 37 billion yen ($400 million from $500 million). Engineers had wanted the lander to be on the surface as early as possible in the mission, so they could use the results it obtained for designing the next-phase missions, but now they will have to wait for a year after SELENE arrives at the Moon.

SELENE consists of a lunar polar orbiter, to study the entire planet, and a relay satellite which will be in a highly elliptical lunar orbit, 100 km by 2,400 km. The orbiter has a mission module and a propulsion-system module. After one year's orbital observation, the 2-ton propulsion module will separate from the mission module, to make a soft landing on the Moon. The relay satellite will be released during the flight to the Moon.

One object of the mission is to measure the gravity field of the Moon. A suite of instruments on the orbiter will also provide data on the chemical and mineralogical composition of the lunar surface, a topographic camera will look at subsurface structure, as will the laser altimeter and the radar sounder, to provide information on the tectonic history of the Moon. The atmosphere of the Earth will be imaged by the Plasma Imager. There is a dust analyzer, charged particle spectrometer, and plasma analyzer.

In addition to these lunar science missions, designed by ISAS, the Institute of Space and Astronautical Science, NASDA is putting government resources in to developing the on-the-ground technology required for the next stages of lunar exploration.

Under NASDA's Office of Research and Development, a variety of rovers is under development. The focus is on automatic, remote-controlled rovers to explore the Moon. The rovers *will* be more capable than the Apollo lunar buggy, or the Soviet Lunokhod, with a goal of operation for one or two years, through many cycles of the lunar day and night. NASDA has engineered a test model to obtain data on running performance, which has also been used for public demonstrations. In the future, rovers should be equipped for resource exploration, topographical ob-

servation, geological surveys, and lunar resource exploitation experiments on the Moon.

In 1995, NASDA also began studying lunar soft landing technology and how to further miniaturize mission equipment and reduce its weight. It already has a mock-up of a landing vehicle.

In order to quicken the pace of lunar exploration technology development, Japan is also forming international alliances to take advantage of the expertise and experience that already exists. On April 20, a space cooperation agreement was signed by Japanese Prime Minister Ryutaro Hashimoto and Russian President Boris Yeltsin. According to a report in *Space News,* the agreement calls for making concrete progress before the year 2000.

Cooperation will kick off with a series of personnel exchanges. Areas that are under discussion are Japanese access to Russian biomedical data and remote sensing technology, and sharing of research on laser transmission in space. Akira Noie, director of the office of research and international affairs on space activities of the Science and Technology Agency of Japan, told the press after the agreement was signed, that one problem in cooperation is chronic funding instability in Russia, which makes the Japanese cautious.

On April 28, the Russian Interfax news agency reported that the world-famed Lavochkin research and production company, which designed and built the Soviet Union's planetary robotic systems, has signed a contract with an unnamed Japanese company for cooperation on exploration of the Moon. According to Lavochkin's deputy general director, Igor Zaitsev, the contract will allow Lavochkin to continue its Moon-related projects, which are now not being funded. Specific areas of cooperation will be discussed in subsequent negotiations, Interfax reports. Lavochkin will participate in an exhibition highlighting Russian space research July 9-Aug. 23 in Japan.

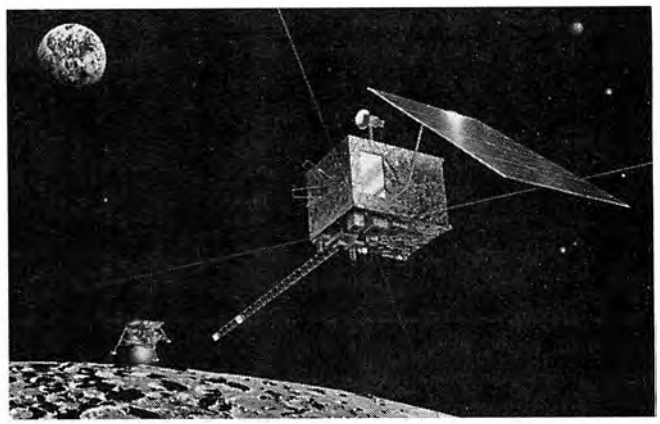
Despite the increasingly uncertain financial situation in Japan, the government and industry seem determined to embark upon a series of precursor missions and research that they hope will prepare them to participate in an international manned lunar exploration program in the coming century.

Among the governments in Europe, there is no similar commitment to a lunar program.

The Fallacy of 'Privatizing' Space

In July 1989, during a celebration of the 20th anniversary of the first Apollo landing on the Moon, President George Bush announced that the United States would formulate a program to return to the Moon, "this time to stay," and then plan a manned mission to Mars. Few then imagined that the President was bluffing, in that he had no intention of organizing a fight for the budgetary support in the government to make that possible, so his speech remoralized space mission planners who had seen little beyond the international space station on the horizon for man in space.

The first International Workshop on Lunar Exploration was held in Beatenberg, Switzerland in 1994. The European Space Agency (ESA) presented its four-phase approach to lunar exploration, culminating in a permanent manned presence on the Moon. But ESA, which engages in new initiatives only with the consent of its member governments, did not have the budget for an additional program at that time. A small internal



National Space Development Agency of Japan

The SELENE mission, to be launched in 2003 by Japan, was to include an orbiter, a lander, and a small communications relay. Although it has been scaled back to only two spacecraft, the orbiter will land after one year of observations, allowing Japan to test techniques for soft-landing spacecraft on another planet.

study was authorized, the Lunar European Demonstration Approach, or LEDA, to look at the critical technologies that would be required for an eventual manned lunar program. Various specific missions were proposed, such as MORO, the Moon Orbiting Observatory, a $400 million-class mission. (MORO lost the competition for a new science mission in November 1996, when the Science Program Committee selected its next, medium-size mission.) In 1995 the ESA Ministerial Council endorsed the general approach, and requested a formal proposal for a small-scale LEDA mission in 1997, which would start in 1998.

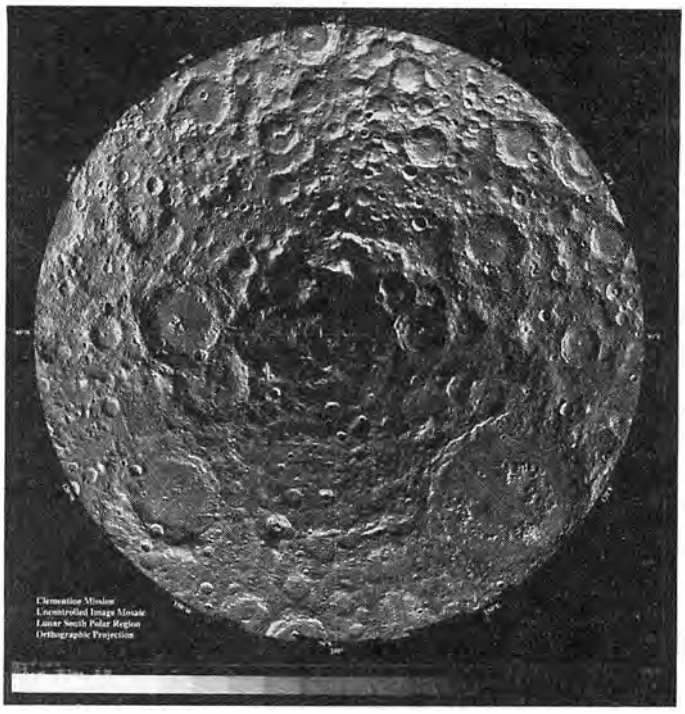
A robotic South Pole Expedition was one mission design, and it was presented to ESA officials in June 1996. It was selected by ESA's long-term space policy committee as a candidate for a "Millennium Celebration" mission, that would be launched in the year 2000. But in November 1997, the south polar lander mission received a "cool response" from ESA's Space Science Advisory Committee, which believed it would be a "burden" to its budget, and some of the supporters of the mission began to seek private funds.

By last year, "Euromoon 2000" had become the lunar program proposal before ESA, predicated on ESA seed money, (about 25 percent of the mission cost), but heavily dependent upon private funding. In a paper presented in October 1997 at the annual conference of the International Astronautical Federation, former astronaut Wubbo J. Ockels, now at ESA's European Space Research and Technology Center in The Netherlands, described Euromoon 2000: The object is to land a spacecraft at a continuously sunlit spot at the south pole at the huge the Aitkin basin. Ockels reported that they had chosen the "Peak of Eternal Light" on the rim of the 20-km Shackleton crater at the South Pole. Euromoon 2000 would be the first in situ investigation of the lunar ice assumed to be at the pole. Costs would be kept down by using existing technology, he said.

Part of the project's budget would be raised through a "dynamic public relations strategy and marketing program." Why would private companies be interested in spending

money on a lunar science mission, for which there was no financial return? Industrial partners formed the EuroMoon Company; a new marketing and advertising consortium to raise funds through "diverse commercial activities." These commercial activities consist largely of a public marketing campaign to "sell" the mission through entertainment, tee shirts, and other paraphernalia with the Euromoon logo, to pay back the cost of the mission.

Euromoon supporters thought they had made ESA an offer it couldn't refuse. But, as Professor Hermann Koelle reports in the April 1998 issue of his *Lunar Base Quarterly*, the ESA council met March 25 and decided not to fund Euromoon, even though industry would contribute the hardware and development costs and take the risk of running the project, and a fundraising consortium was already working out a plan to finance it. Prof. Koelle, who is one of the founders of the international lunar development initiative, believes that, "If no counter will be taken, Europe will step out of any Lunar Exploration activities." These days, even with only one quarter of the cost coming from government resources, the European nations have opted out of lunar exploration.



U.S. Geological Survey

The radar results from the Clementine spacecraft, and more recent data from the Lunar Prospector, indicate that there may be large caches of water ice in permanently shadowed craters at the lunar poles. Missions to do the more intense exploration, including a landing at a polar site for in situ prospecting, must be seen not as entertainment, but as the next step in a long-term program to bring human civilization in to space.

The prevailing attitude was expressed by Italian Space Agency manager of automation and robotics, Simonetta Di Pippo, at the second International Lunar Exploration Working Group (ILEWG) meeting held in October 1996 in Kyoto, Japan. As reported in *Space News,* she said that the world's space agencies must develop "affordable, incremental Moon missions that can capture the imagination of taxpayers."

For their part, the majority of the scientists, researchers, mission planners, and visionaries who make up ILEWG, agreed at the same meeting that there was no real alternative to initial government support, stating: "[F]or development of commercial resources, the role of government appears to lie in contributing to infrastructure development, technology advancement, environmental protection, and commercial regulation. The role of industry is to develop and operate production and distribution systems."

Serious people, who have been working on lunar missions for decades, such as Prof. Koelle and a core group in Houston, Texas, know that the first steps of a great project, such as moving human civilization into space, will not be funded by selling "entertainment." But in this age of dwindling budgets, as the international speculative financial bubble consumes more and more of the resources that are needed by societies today, as well as tomorrow, various "get-rich-quick" schemes are being pursued to try to fund lunar exploration programs.

Even a 1997 paper by the Shimizu Company proposes that, like the Olympics, "Entertainment" and "Competition" will be important factors for the commercialization of events, and "may also be applicable to the commercialization of space activities, including lunar resource utilization." The paper quotes figures of how much money is spent by Japanese citizens on horse racing, speedboat racing, and a Japanese version of pinball machines. Their conclusion: "One of the most feasible approach to secure sufficient funds for future lunar resource utilization would be the utilization of space activity's attractiveness as a public entertainment. . . . The general public could participate in these events at small personal expenditures."

This "free market" approach to space science and exploration is nowhere more prevalent than in the United States. LunaCorp was established in 1989 by David Gump to "find non-government funding" for a commercial mission to the Moon. Their plan is to land a pair of remotely operated robotic vehicles on the Moon. Funding for the $200 million project is to come from corporate sponsors, science researchers (!), TV networks, and amusement parks. The attraction is supposed to be the ability for people to teleoperate the rovers around historic sites, such as the Apollo 11 landing site, and those of unmanned landers on the Moon, for a fee. A similar proposal is being pursued by International Space Enterprise, based in California.

However, not every idea of how to bring the creative and investment potential of the American private sector (as opposed to the entertainment "industry") into lunar industrial development is based on a gimmick.

Former Apollo astronaut Harrison Schmitt, with colleagues at the University of Wisconsin, have put forward the formation of Interlune, as a private effort to start industrial exploration by landing rovers on the Moon to further analyze the regolith for the abundances of helium-3 and other materials, after the transportation and infrastructure for lunar development is in place.

Marsha Freeman

Krafft Ehricke (left) is presented with a painting of lunar industrialization by Dr. Michael Duke, after Ehricke's talk at a 1984 conference on Lunar Bases and Space Activities of the 21st Century in Washington, D.C.

Colorado lawyer and space enthusiast Declan O'Donnell is organizing support for the establishment of a Lunar Economic Development Authority, which would both develop the private capital resources for long-term industrial development, and begin to lay out the legal and commercial framework for it.

Those who feel they might succumb to the pessimism about national space programs, and propose to create an "entertainment industry," or rely on corporate altruism to support lunar exploration, should study carefully the experience of Dr. Alan Binder, the organizer and principal scientist for the current Lunar Prospector mission. At a briefing in Washington on Dec. 4, 1997, a month before Prospector's launch, Binder related that at the end of the Apollo program, in the early 1970s, the scientific community agreed that the next step was intensive mapping of the Moon, from polar orbit. Not able to secure NASA funding, a group of scientists, led by Binder, concluded that if they worked without pay (which they were willing to do), and the then-Soviets would launch the group's spacecraft free on a Proton rocket (which they agreed to do), then the group would just need about $10 million in cash, and donations of hardware and equipment, from U.S. industry for the mission to fly. But Binder and his colleagues were never able to find sources to donate either the cash or the hardware. They persistently pressed for a NASA program to accomplish the task, and finally got it off the ground, and to the Moon.

There are no future missions to the Moon currently on NASA's agenda.

In the Footsteps of Krafft Ehricke

At the end of October 1984, a small group of planetary scientists and mission planners from NASA's Johnson Space Center organized a conference at the National Academy of Sciences, in Washington, D.C., on Lunar Bases and Space Activities of the 21st Century. The featured presentation was given by Krafft Ehricke, who, while gravely ill with leukemia, agreed to speak. He held the audience spellbound as he presented the concepts for lunar colonization that are summarized in the first part of this article.

The year before, in March 1983, before they were aware of Krafft Ehricke's work, one of the conference organizers, Wendell Mendell, gave an interview to *Fusion* magazine, during a meeting he, Michael Duke, and Barney Roberts had organized at the Johnson Space Center, on returning to the Moon. Mendell reported that in 1981, when the Reagan administration came in to office, it proposed deep cuts in space science programs, including the closure of the Lunar Curatorial facility at the Johnson Space Center.

"We had always been lunar advocates here because of our scientific heritage in the Apollo program, and work with lunar samples," Mendell explained. NASA was concentrating on "near-Earth space," and "that phrase caught me. I began thinking about it, and then came to the realization that the Orbital Transfer Vehicle going to geosynchronous orbit [from an Earth-orbiting space station] would have the capability to go to lunar orbit. It is 10 times the distance, but it is equivalent energetically. That does not mean land on the Moon, but that means you can get into lunar orbit."

"It was clear to us that the Moon was part of near-Earth space. Nobody realizes that. . . . It's too close not to do it. It's a 'freebee' in a sense."

In an article published in *Space Policy*, three months after the Lunar Bases conference, authors Duke, Mendell, and Roberts state that the Apollo missions "have provided the technology and the information necessary to fulfill a greater dream—the transport of civilization beyond the confines of the Earth." The purpose is to develop "our dual planet system."

The vision of Krafft Ehricke is reflected in Mendell's recent article, in the May/June 1996 issue of *Ad Astra:* "The real vision is (and should always have been) the creation of a space-based civilization." One principle function of the lunar base, Mendell states, "is the establishment of industrial processes to support the base or to export products to other space activities." He describes some of the particular technologies that could be used for the mining of lunar oxygen, as an enabling activity for lunar industrialization, and concludes, "Krafft Ehricke, one of the great minds of our era, understood both the technological and ontological aspects of what he called 'The Extraterrestrial Imperative.' " But this vision is not so easy to maintain. Just a year earlier, NASA Administrator Dan Goldin had foolishly challenged mission planners at Johnson Space Center to come up with a scenario to send astronauts to the Moon by the year 2001—with only $1 billion.

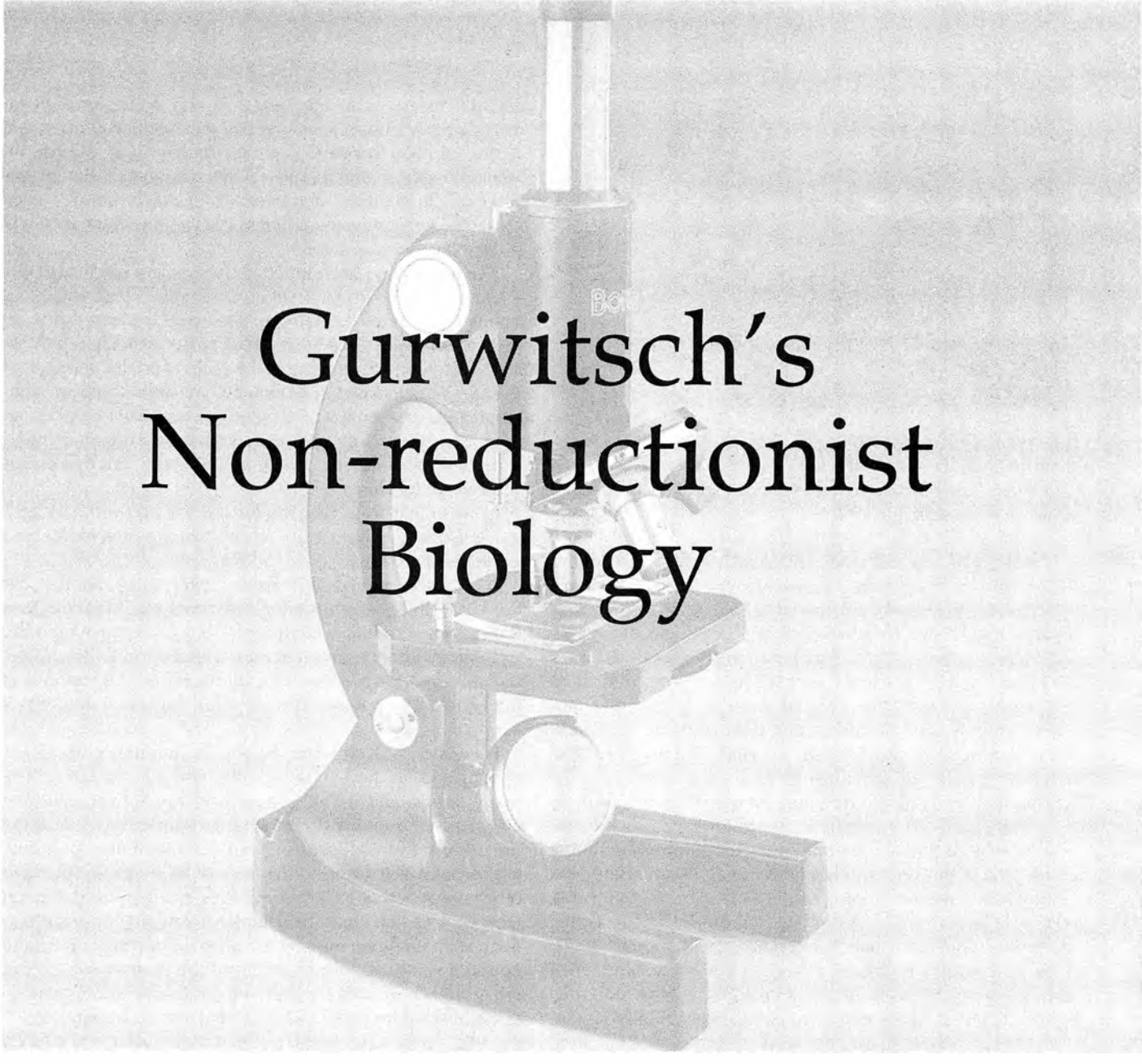
In introducing Krafft Ehricke's featured presentation at the conference on Lunar Bases in Washington in 1984, Fred Durant, who met Krafft Ehricke in 1952, when Durant was active in the American Rocket Society, noted, ". . .[I]t is a lonely world where Krafft lives part of the time, because it is the future."

Whether that future will be the fulfillment of the vision that Krafft Ehricke had for it, is now the responsibility of those of us who have come after him.

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

Notes

1. See, for example, Marsha Freeman, 1997. "Making Sure We Never Get to Mars," *21st Century*, Spring, p. 71.



Gurwitsch's Non-reductionist Biology

Alexander Gurwitsch: Father of Biophysics

INTRODUCTION

The work of Alexander G. Gurwitsch is hardly known by scientists in the West today, yet he may rightly be considered as the father of biophysics. Gurwitsch sought the causality underlying living processes, and his experiments were the first to reveal part of the electromagnetic organization of the living state.

Gurwitsch concentrated on two main areas related to this problem. The first was the development of the embryo, and the second, the process of mitosis. Gurwitsch was fascinated by the experiments of Hans Driesch (1867-1941) in embryology, which emphasized the role of the embryo as a whole, in directing the course of development. Driesch had successfully separated a two-cell echinoderm embryo, and each half grew normally into a complete adult organism. From this, and other experiments, Driesch had ascribed to embryonic cells a property of equipotentiality, and raised the question of what caused the development to proceed. Driesch himself thought that the actual cause of this development process was unavailable to scientific analysis; Gurwitsch, however, used this as the starting point for his work in embryology. Although Gurwitsch adopted Driesch's conception of the whole organizing the development of the embryo, he remained a close friend of Wil-

34 Introduction: Alexander Gurwitsch:
Father of Biophysics
by Colin Lowry

36 Alexander Gurwitsch and the Concept of the Biological Field
by Michael Lipkind

52 Remarks on Gurwitsch's Method
by Lyndon H. LaRouche, Jr.

helm Roux, (the founder of the mechanistic approach in embryology) who encouraged Gurwitsch to experiment, and always published Gurwitsch's papers in his journal.

One of Gurwitsch's important experiments in embryology, used a centrifuge to disrupt the organization of the visible structures of an early embryo. The embryos that were disrupted by this technique still developed normally, usually after reforming the visible structures in the cytoplasm. From this result, Gurwitsch hypothesized that the restoration of the visible structures in the embryo, was organized by "invisible structures," or, a dynamic force that remained undisturbed. From this hypothesis, Gurwitsch developed his conception of a "biological field," which was the electromagnetic organizing force of the living state, a concept he refined over the course of decades of experimental work.

Mitogenetic Radiation

Gurwitsch's study of the initiation of mitosis led to the discovery of "mitogenetic radiation" in 1923, for which he was widely known throughout the West in the 1930s. Gurwitsch had found that cells undergoing mitosis, emit radiation in the form of photons in the ultraviolet range, which could trigger mitosis in other cells. Using onion root tip meristems, which have a large population of mitotic cells, Gurwitsch tested whether a root tip brought toward another root meristem, could induce increased rates of mitosis. The result was a 20 to 25 percent increase in mitotic cells in the other root meristem. However, the effect could be eliminated, if a glass plate that absorbed ultraviolet radiation were inserted between the roots. These initial experiments were followed by hundreds more, using early photon detectors, and other methods, to analyze the spectroscopy of the emitted radiation.

This crucial discovery raised many questions as to what was the source of the emission of this photon radiation, and how such a small amount of energy could trigger a process as complex as mitosis. Gurwitsch viewed the living cell as a coherently organized system, containing "unbalanced molecular constellations," which required an input of metabolic energy for their existence. The disruption of metabolism in the cell, he said, will cause the breakdown of these molecular constellations, and the subsequent release of the stored energy.

To test this hypothesis, Gurwitsch observed the release of energy from dying cells, and also from reversible perturbations of metabolism, such as cooling and light narcosis. In each of these cases, the cells emitted photon radiation very similar to that found in mitotic cells. Gurwitsch called this "degradational radiation."

At that time, most scientists who were convinced of the phenomenon of mitogenetic radiation, did not know what to do further, and did not see the real physical and biological implications of the discovery. But Gurwitsch then took his investigations of mitogenetic radiation to the molecular level. Experimenting with solutions of purified proteins, he found that when weak electric and magnetic fields were applied to the proteins, and then removed, the proteins emitted ultraviolet photons, similar to degradational radiation. At this point, Gurwitsch's theory of the biological field came to maturity, as he could now explain the relationship of events from the molecular, cellular, and organismal levels.

Optical Biophysics

Gurwitsch's pioneering work formed the basis of "optical biophysics," and later investigations into the electromagnetic organization specific to living systems. Recent work on biophoton emission has shown that DNA is the major emitter and absorber of photon radiation in the cell, and this may be directly related to its important role in the regulation of growth and metabolism. Much of the current work that traces its conceptual lineage to A.G. Gurwitsch's biological field, focusses on the coherence of the living state, in restricting the random, thermal motion of molecules, thus making possible resonant effects triggered by small amounts of energy.

The scientific method employed by Gurwitsch runs contrary to the linear, Aristotelian approaches that dominate biology today. The study of Gurwitsch's ideas and his life's work thus may serve as a friendly guide for those who wish to break free of the Aristotelian axioms of today's science.

—Colin Lowry

Alexander Gurwitsch And the Concept Of the Biological Field,

Part 1

by Michael Lipkind

Alexander Gavrilovich Gurwitsch (1874-1954)

From archives of L. Beloussov

A student of the great biologist discusses the importance of Gurwitsch's thought and his work.

A great deal could be said about the remarkable life of Alexander G. Gurwitsch, spanning the juncture of two centuries and nourished by two great sources of culture: specifically Russian (he was born and brought up in Russia and spent most of his life there), on the one hand, and Western European, particularly German, on the other (he studied, graduated and began his scientific activity in Munich and continued his work in Strasbourg and Bern). Much could be said about his brilliant intellectual power: By the cast of his mind he was a typical theoretician possessing a rare combination of deep philosophical intuition, with an incredible gift of experimental inventiveness. He comprehensively analyzed all facts and phenomena in an intrinsically vitalistic manner—vitalistic not in an agnostic sense, but in a working sense of this notion. He had a deep devotion to scientific and humanistic principles, together with a tolerance of opposite views, and kindness to all those he met.

An example of his crystalline adherence to principles was his resignation in 1948 from the post of the Director of the Institute of Experimental Biology in Moscow, as a protest against the Lysenko dictatorship in Soviet biological sciences. At that time, this was an act fraught with mortal danger which, fortunately, only made him fall into disfavor until the end of his days.

A peculiarity associated with his works is the quaint fate of some of his findings and ideas which have become a sort of "scientific folklore" when the authorship at times is forgotten.

However, this panegyric can be considered the personal emotional feeling of one who was lucky in his adolescence to become acquainted with Gurwitsch, and to hear from him about the innermost mainsprings of living processes. Some facts about his life should be added.

Alexander Gavrilovich Gurwitsch was born in September 1874, in Poltava, Ukraine, into an educated Jewish family. In his youth, he displayed an inclination to music and painting, and after finishing gymnasium in 1892, he moved to Munich to join the Munich Academy of Fine Arts. He failed the examinations, and instead entered the Medical Faculty of the University of Munich. Very quickly he became keen on the biological sciences, and from the third year started his scientific activity in the laboratory of Professor Karl von Kupffer, a distinguished anatomist and morphologist. Gurwitsch's first work, concerning the influence of the chemical composition of the medium on amphibian development, was published in 1895. In 1897 he graduated from the University of Munich and continued working in Kupffer's laboratory until he obtained a position in the Department of Anatomy of the University of Strasbourg. Here, and later in the Department of Anatomy of the University of Bern (1901-1905) he worked in the fields of embryology, histology and cytology.

In 1903, Gurwitsch married Lydia D. Felicina, who was a Russian student at the University of Bern Medical Faculty, and who subsequently did her doctoral thesis under his supervision. Apart from the great general influence of her personality on the scientific creativity, and the whole life of Gurwitsch, she became an unfailing collaborator of her husband, and co-author of many of his works on mitogenetic radiation.

In 1905 the couple returned to Russia, and soon after, Alexander became professor of anatomy and histology at Bestuzhev High Women's Courses in St. Petersburg. His work there continued until the October Revolution and Civil War of 1917. The St. Petersburg period was one in which his general conceptual view of biological problems was substantially formed. He began there as a highly erudite biologist with an excellent background in physics and mathematics—rare among biologists, especially at that time. During this period his inherent inclination toward understanding the whole enigma of the essence of the living state became focussed on two main

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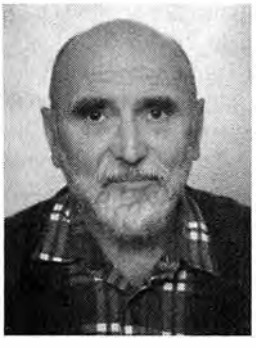


Michael Lipkind was born in Moscow in 1934, and was personally acquainted with Alexander Gurwitsch in his youth. Gurwitsch's brilliant intellectual power, original scientific and philosophical vision, humane personality, steadfast honesty and generosity during a cruel period of Russian history, strongly influenced Lipkind, who considers himself as Gurwitsch's disciple. In 1952, Lipkind attempted to join the Biological Faculty of Moscow University, which was hopeless for a Jew at that time. Then, as a student at the Moscow Medical Institute, Lipkind worked in Gurwitsch's Laboratory of Mitogenetic Radiation, and attended a private course of lectures given by Gurwitsch in his apartment, in the last year of his life. There were only three listeners: Anna Gurwitsch (his daughter), Lev Beloussov (his grandson), and Lipkind.

In 1958, Lipkind graduated from the Moscow Medical Institute but was not allowed to work in Gurwitsch's laboratory. Instead, he was sent to Siberia for three years, to work as a medical doctor. Without the possibility of working in the Laboratory of Mitogenetic Radiation, Lipkind subsequently joined the Institute of Virology, and pursued a career in the field of general and molecular virology. In 1974, he emigrated to Israel, where in addition to his "official" work, he returned to his "old flame," biophysics.

Lipkind is currently a research professor of virology at the Kimron Veterinary Institute, in the Volcani Center for Research in Agriculture, in Beit Dagan, Israel. Since 1987, he has been a member of the Board of Directors of the International Institute of Biophysics (Neuss, Germany), whose main research focus is biophotonics, which is a continuation of Gurwitsch's mitogenetic radiation.

Lipkind's scientific interests range from virology and cell biology to biophotonics and the theory of the biological field. This theory—the topic of this article—Lipkind considers an unprecedented attempt to formulate a non-tautological vitalistic principle. The theory has the form of a mathematical model based on strictly defined postulates that are deeply rooted in biology. Consequently, it has the potential to become a powerful tool that would work when applied to all three levels of biological organization: molecular, cellular, and organismal.

Lipkind's article was edited by Colin Lowry and David Cherry. Part 2 will appear in the next issue of 21st Century.

problems: the regularities of formative processes in embryonic development, on the one hand, and the "miraculous phenomenon of karyokinesis" (mitosis, in his expression), and its initiation factors, on the other. The way to understand the former problem was based on constructing some "supraprinciples" intended to explain various processes occurring in a living system and displayed at different levels of its organization. Precisely during this period, the notion of "field" used in physics was applied by Gurwitsch for the first time for the analysis of morphogenic phenomena.

In St. Petersburg, Gurwitsch was one of the initiators and active members of the "Circle of Small Biologists," which emphasized the conservative arrogance and stagnation of the established universities' "Big Shots."

In autumn 1918, Gurwitsch and his family moved to Simferopol, Crimea, where he headed the Histology Department of the newly founded Tavria University until the end of 1924 (where he became a friend of the famous geochemist Vladimir Vernadsky). The Crimean period was one of the most fruitful in his life. In conditions of practical isolation from the Western world during 1918-1921, he concentrated on two main topics: the further development of the concept of the morphogenic field and its application in various embryological models, and a dualistic conception of the initiation of mitosis. The latter led Gurwitsch to the discovery of mitogenetic radiation in 1923, which brought him a worldwide reputation.

In 1924, Gurwitsch was elected professor of the Department of Histology and Embryology of the Moscow University Medical School, where he worked until 1930. This first Moscow period was marked by intensive studies on the newly discovered phenomenon of mitogenetic radiation, which was widely recognized in the Soviet Union and in the West. A newly elaborated method of biological detection of mitogenetic radiation, using budding yeast culture, proved to be a powerful tool. He also applied the conception of the morphogenic field to some other embryonal models. This was the period of the establishment of Gurwitsch's school within Soviet biology, which included his old students of the Western and St. Petersburg periods, V.V. Polovtseva and, A.A. Lyubishchev; his students from the Crimean period, S. Salkind and G.M. Frank; and his new Moscow students, M.A. Baron, L. Blyacher, M.A. Vorontsova, V.F. Eremeev, A.P. Potoskaya, N.N. Kannegisser, and V.A. Dorfman. At the end of this period, Gurwitsch's classic work, *Histologischen Grundlagen der Biologie* (Histological Foundations of Biology) was published in Jena in 1930.

In 1927, Gurwitsch was invited to Germany, along with a number of distinguished Soviet scientists, this being his first visit abroad since the October Revolution of 1917. At an official reception in Berlin, Gurwitsch met Albert Einstein. In a short discussion with Einstein, Gurwitsch indicated difficulties in finding energy sources in living systems sufficient for the emission of high-energy ultraviolet photons. Einstein expressed his confidence that, like any factual finding, the study of mitogenetic radiation would reach the point at which a purely physical explanation of its energy sources would be found.

At the end of the 1920s, Gurwitsch came to be seen as a symbol of heretical free-thinking by the university authorities. An inevitable conflict occurred in 1929, and Gurwitsch left Moscow University.

In 1930, Gurwitsch was offered a position at the Research Institute of Experimental Medicine in Leningrad. This was the first research institute in Russia not affiliated with any university. It was established in 1890 on the pattern of the famous Pasteur Institute in Paris, founded only two years before. He was given a laboratory in the newly established Leningrad Institute of Roentgenology and Radiology. For the first time, he was able to plunge into pure research without any teaching obligation.

The Leningrad period was marked by further intensive studies using mitogenetic radiation as a powerful tool for analyzing the molecular substrate of various living systems—plant, animal, and microbial. The application of mitogenetic radiation methods to various biological problems led to the development of essentially new views and conceptions when applied to neurophysiology, biochemistry, and carcinogenesis. At that time, the phenomenon of degradational mitogenetic radiation was found (emitted by dying cells) and became the basis for the concept of "non-equilibrated," unbalanced molecular constellations. This phenomenon underlay the theory of the vectorial biological field.

During the Leningrad period, Anna Gurwitsch, Alexander Gurwitsch's daughter and successor, began working in the field of mitogenetic radiation.

In January 1934, Gurwitsch was invited by the Vienna Biological Society, the Pasteur Institute, and the Holland Student Association, to read a series of lectures on mitogenetic radiation in Vienna, Paris, Amsterdam, Leyden, Utrecht, and Groningen. In the autumn of the same year, he participated in the International Congress on Electroradiobiology in Venice, where he presented a report on "The Contemporary State of the Problem of Mitogenetic Radiation." During these two visits to the West, which turned out to be his last, Gurwitsch became acquainted with the main Western researchers working on mitogenetic radiation.

In autumn 1941, Leningrad was beseiged by Nazi troops. In conditions of starvation, Gurwitsch and his family, along with other scientists, were evacuated to Kazan on special planes. Here, in hard wartime conditions, without any possibility for experimental studies, he concentrated fully on purely theoretical work, and here, his field theory acquired its final form under the name of the vectorial biological field. It was published in Russian in 1944, and, after the war, in French in Leyden (1947).

Immediately after the war, Gurwitsch was appointed director of the Institute of Experimental Biology, which was affiliated with the newly established USSR Academy of Medical Sciences. He was the head of the Department of Mitogenesis at the Institute during the same period. The appointment lasted until August 1948. This was a period of intensive experimental studies, especially on the application of mitogenetic radiation analysis to the problems of neuromuscular excitation and carcinogenesis. Gurwitsch was also involved in an experimental analysis of karyokinetic (mitotic) phenomena by means of the postulates of the theory of the vectorial biological field—the work was carried out by L.Ya. Blyacher and E.Ch. Puchalskaya.

During the Leningrad and second Moscow periods, Gurwitsch's scientific school acquired a number of talented researchers and ardent followers: E.S. Billig, L.D. Lyosner, B.S. Pesochensky, E.Ch. Puchalskaya, and N.S. Slavina.

In 1948, the notorious August Session of the Academy of Agricultural Sciences, organized by T.D. Lysenko, took place. This was the beginning of the gloomiest period for the Soviet biological sciences—the period of forced obedience to primitive obscurantist dogmas in all branches of biology. In such a medieval atmosphere, Gurwitsch, unlike most scientists at the time, made the only possible form of protest: He submitted his resignation and retired. At the time, Gurwitsch was 74 years old, and remained full of creative activity. Working at home, he practically directed the laboratory of mitogenesis, which was more and more cut off, until its liquidation in 1953. Although it was re-established soon after, its personnel included only two in tenure track positions, Professor Anna Gurwitsch and Dr. Victor F. Eremeev. However, a number of young volunteers, students, and employees of various institutions worked in the laboratory, which was crammed into one, and later, two rooms.

At that time, most of Gurwitsch's efforts were concentrated on his last work, *Analytical Biology,* which included the main epistemological premises for theoretical biology, and the fullest description of the conceptions of his theory of the vectorial biological field. This book has not yet been published, and still awaits its readers. Only Gurwitsch's close followers have read the manuscript. I myself, by just a lucky chance, had the privilege to be one of a few listeners to the course of lectures which Gurwitsch read at home during 1953-1954, just before his death on July 27, 1954.

The Biological Field Theory: Prerequisites, Origin and Conceptual Development

Gurwitsch's central theoretical work was the development of the concept of the biological field, which he first introduced into biology as a notion of "field" that had previously belonged to the vocabulary of physics. In his 1912 paper, "Die Vererbung als Verwirklichungsvorgang" (Heredity as a Process of Realization), the notion of field was associated with the conception of the co-subjection of elements to a common morphogenetic factor, as opposed to an alternative conception considering the whole morphogenesis as a result of interactions among the elements. Gurwitsch's field conception underwent successive developments, from the first abstract models describing single morphogenetic phenomena, to the general theory of the vectorial biological field dealing with all the levels of organization of the living organism—morphological, cellular, and molecular.

Historical Background

At the turn of the 20th century, when Gurwitsch started working on the whole problem of ontogenesis, several new developments in biology became key influences on the formation of his biological concepts. The first was the rediscovery of the basic laws of formal genetics discovered by Gregor Mendel in 1864, and the second, the crucial experiments in embryology performed independently by Wilhelm Roux (1850-1924) and Hans Driesch. The studies initiated by Roux led to the establishment of a new branch of developmental biology, the mechanics of development (Entwicklungsmechanik), which flourished, and which culminated in the famous experiments by Hans Spemann and Hilde Mangold (1924). Spemann's experiments resulted in the discovery of "embryonal induction," the inductive capacity of a particular part of an embryo transplanted onto another to determine the morphogenic fate of the local tissue surrounding it. The experiments performed by Driesch on harmonic regulation in the embryo, underlay the establishment of a clearly expressed vitalistic conception.

Any theory of development or heredity, no matter how complicated, at that time was based on one of two basic theoretical concepts—preformism or epigenesis—which had dominated the minds of biologists from the very beginning of scientific biology, often serving as "supreme" principles. The roots of preformism can be traced back to Hippocrates, while the idea of epigenesis comes from Aristotle.

According to the logical structure of preformism, the zygote (fertilized egg-cell) contains all the potential prerequisites for the development of a future organism, with all its specific patterns, features, and properties. Evidently, the original concept of preformism considered the whole chain of events constituting the embryo's development to be "predestined" by these potential prerequisites. However, this original, general definition of the principle of preformism gave way to a modified concept based on the idea that all the observed complexity of the organism, can be reduced to separate independent features that can be projected onto strictly determined, separate entities contained in the zygote. These entities are responsible for all the actual species-specific features. Using the contemporary vocabulary, one can define such entities as genes and, accordingly, classic Mendelian genetics can be considered a pure form of this kind of preformism.

As to the classical embryological preformism, the zygote presents a puzzle-like (mosaic) spatial distribution of the entities inside it, with each entity being responsible for a certain morpho-anatomical part of the future organism. Thus, the development of the embryo is just an evolution of these preformed and predetermined entities. Accordingly, there are rigid, unequivocal connections between each such entity and the corresponding part of the embryo: Hence, each ontogenetic stage can be reduced by projection backward, through the chain of all previous stages, to the initial stage which is the zygote itself.

Epigenesis, in its initial form, was just an alternative to preformism. According to its logic, any momentary stage of an embryo's development can be deduced from an immediately earlier stage only, but not from one several steps earlier. Thus, contrary to preformism, no stage of the embryo's development has a direct, unequivocal prerequisite in the zygote: The zygote has the prerequisite only for the first act of the whole development. Similarly, any stage of the whole chain of development contains only an actual prerequisite for the stage immediately following it. These are epigenetic actual prerequisites as opposed to the preformistic potential prerequisites. According to this approach, the developing embryo system presents a combination of partly independent and partly non-rigidly associated processes. If one analyzes the development not in the genealogical, but in the chronological order, at a certain stage something new appears without any visible prerequisite, and it, in turn, is a prerequisite for the next stage.

The doctrine of developmental mechanics was founded by Wilhelm Roux, together with the "causal-analytical" method in embryology (1895), according to which the embryo is compared to a complicated mechanical gadget. In order to under-

stand how this mechanism works, one should know how it is constructed and what part acts on another during development. In other words, one should know the localization of the causes of development. In this respect, the main problem is to know whether the cause of the development of a certain part of the embryo is localized in this very part (self-differentiation), or needs the influence of another part, or from the external environment (induced differentiation). One approach to solving this problem is to change the local environment: to isolate this part, to combine it with another one, or to change the external environment, having in mind to reveal the causal connections.

The general problem of embryology, according to Roux, is the formation of visible heterogeneity from something invisible, the main research task being to reveal the causal connections between these two states: invisible heterogeneity—visible changes. As to the nature of this invisible heterogeneity, whether it is predetermined (preformism) or appears de novo (epigenesis), Roux himself hesitated, while other followers of the causal-analytical method, such as W. His and R. Lancaster, adopted preformism.

In 1887, Roux raised the question of whether the development of two blastomeres depends on each other. He used a frog embryo at the stage of two blastomeres (two cells) and killed one of them with a red-hot needle. The remaining blastomere developed into only half of the embryo, which seemed to support the principle of preformism.

However, Hans Driesch performed a similar type of experiment in 1891, mechanically separating two blastomeres from a sea urchin embryo, which produced a crucial result: From each blastomere, the *whole* embryo developed without any morphological defect. The development of the whole from a part was called by Driesch "embryonal regulation." Afterwards, it was shown that the technical approach used by Roux was not suitable, because the remaining, killed blastomere prevented the other live one from developing properly. Driesch performed other experiments, using various organisms such as Coelenterata, Echinodermata, and Ascidia, which consisted of perturbing various parts of an embryo, as well as mixing some of its parts. His results were similar: formation of a normal embryo after drastic interventions into its normal development. One of the impressive results was the development of a morphologically normal Hydroid embryo, after a single cell was removed at the 32-cell blastomere stage.

Such general phenomena were called by Driesch "harmonic regulation." Driesch's harmonic regulation was demonstrated on the embryo level, that is, after cleavage of the egg. More recent experiments on intracellular manipulation have shown that suction of about one-fourth to one-third of the zygote cytoplasm will be followed by the development of a normal embryo.

Driesch drew important and far-reaching conclusions from his experiments. He suggested two principal notions: equipotentiality and equifinality. The former means that all the elements (cells) of a whole (embryo) are equal in their potential morphogenic capability, each having a full set of possible potencies. The latter means that the final result of the development—formation of a highly specific mature organism—may be reached by quite different paths. Thus, the two notions are the very expression of the epigenetic principle, as opposed to the preformist one: There is no intrinsic predetermination of an element's individual destiny, nor is there a rigid spatial distribution of the prerequisite entities inside the zygote, with exactly scheduled specific roles for each one in development.

These considerations led Driesch to his classic general conclusion: The fate of the element is a function of its location within the whole. The whole was called by Driesch a "harmonic whole," to which he ascribed a teleological property, a factor of realization of the purpose of development. This he called *entelechia* after Aristotle, and defined it as a non-material, non-spatial, metaphysical factor that leads and organizes the development of the embryo, even if its parts are drastically perturbed, mixed, or deleted. Thus, designating *entelechia* as *vis vitalis* (living force), Driesch gave the name "vitalism" to his doctrine (Driesch 1908, 1915) and counterposed it to Roux's causal-analytical method.

Apart from the factual contribution of both schools, the confrontation arose from differing philosophical backgrounds, namely, different definitions of the notion of cause. The vitalistic conception developed by Driesch was based on the notion of the final cause (purpose) (Aristotle's *causa finalis*) while the causal-analytical method of Roux was based on the notion of the immediate (acting) cause. Considering *entelechia* to be unavailable to rational analysis, Driesch himself left experimental science, having discouraged any potential followers from exploring this direction. The causal-analytical school founded by Roux, and highly developed by Spemann (1936), attracted many followers, and has determined the face of contemporary embryology.

Upon this background, the field conception developed by Gurwitsch became an alternative challenge to the principle of preformism underlying the dominant trend of contemporary biology.

Gurwitsch's Critical Analysis Of the Main Theoretical Conceptions in Biology

Gurwitsch's attitude toward the purely descriptive studies in morphology (cytology, histology) of that time was clearly negative, especially when such studies were followed by arbitrary and speculative interpretations, which was very often the case. This reflected his negative view toward studies performed blindly, according to the "let's see what we get" approach. His scheme of research consisted of a comprehensive deductive analysis from all the facts related to the problem, inductive construction of a working hypothesis, and then its experimental examination. Certainly, this is rather a general (perhaps truistic) scheme of a proper scientific analysis, but the history of science shows that the scheme has been carried out only in the really distinguished cases. In Gurwitsch's case, his capacity for deductive analysis was remarkable for its wide scope of included facts related to different fields of biology: Confrontation with these facts led sometimes to unexpected conclusions. Such a wide scope was based on his vitalist philosophical orientation, which permitted him to foresee a common principle in quite different biological phenomena. Correspondingly, the inductive part of Gurwitsch's analysis was intrinsically original and bold. As to the experimental examination of his conceptions, the best example is the discovery of mitogenetic radiation, which, like the discovery of Pluto, was done "at the tip of a pen."

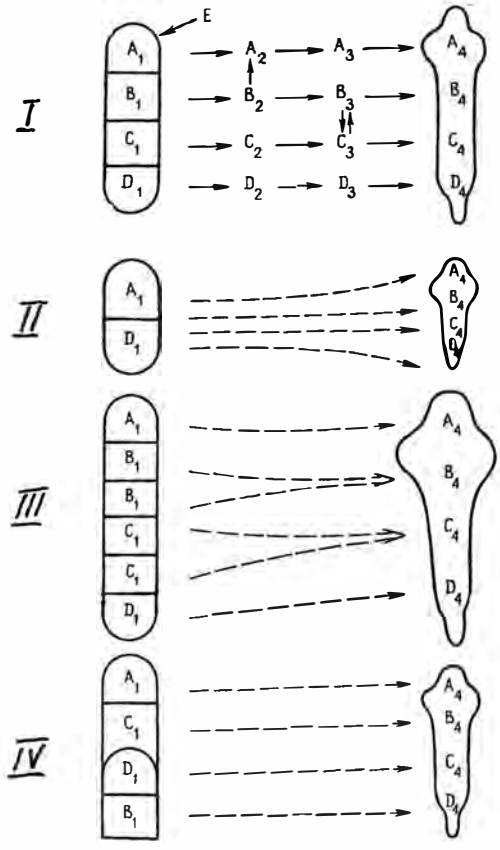


Figure 1
CAUSAL MATRIX OF DISTINGUISHABLE COURSES OF DEVELOPMENT

Schema of the mechanics of development (Entwicklungsmechanik) proposed by Wilhelm Roux (I). Hans Driesch's concept of harmonic regulation is illustrated in the remaining sections. The embryonic material undergoes excision (II), addition (III), and disturbance (IV).

Source: Beloussov 1980

The revived formal genetics, in the original description by Gregor Mendel, highly fascinated Gurwitsch by its logical, almost mathematical strictness. However, very soon he understood that formal genetics, by its definition of the gene, as well as by its "evident" conviction that the whole organism may be resolved in full into Mendelian features, could not logically explain the realization of morphogenesis itself. In his paper, "Heredity As a Process of Realization" (1912), Gurwitsch wrote that embryogenesis itself turned out to be beyond the consideration of Mendelian genetics, which treated the transfer of hereditary features as if it were an isolated process apart from embryogenesis. The point is that the gene, by definition, is characterized by chemical parameters, determining the mechanism of its action. (One should take into account that all these considerations were made when nothing was known about the structure of the gene, although the same logic is relevant for the case of modern genetics based on the universal biochemical code.) Thus, the mechanism of gene action inside the cell logically is free of contradictions. However, most of the Mendelian features appeared to be collective phenomena involving many cells in their realization.

Gurwitsch gives an example of the Mendelian features of smooth and jagged contours of a nettle leaf. Evidently, the realization of such a feature is the result of specifically directed movements and mitoses of many cells into the corresponding leaf contour, but the gene in each of these cells is not able to guide such actions. The gene "speaks cellular language," while the feature is realized on the supracellular level. Gurwitsch did not see a solution to this contradiction within genetics.

Roux and Driesch had obtained experimental results concerning the separate temporal determination of the anterior-posterior and the dorsal-ventral axes of the developing amphibian limb. Harrison (1918) had done striking related experiments on the transplanted amphibian limb, and Gurwitsch subjected the theories of the two schools of thought, mechanistic and vitalist, to a comprehensive analysis on this question of determining axes in the embryo. This analysis can be well demonstrated with the scheme of a causal matrix (Figure 1) presented in L.V. Beloussov's *Introduction to General Embryology* (1980).

According to Roux's scheme (Figure 1, I) there are some strict causal connections originating from factors localized in the egg (A1, B1, C1, D1), and through intermediate stages 2 and 3, they lead to the respective "final products" projected on a final stage of the matured organism (A4, B4, C4, D4). In addition to these immediate connections, there may be influences (mainly at the initial stages of development) from the external environment (E → A1) as well as unilateral or bilateral influences of different parts of the embryo on each other (B2 → A2; C3→B3). According to this scheme, the development cycle can be completely and unequivocally resolved into separate causal connections, and the aim of analysis was thought to be the deciphering of these connections. This conceptual approach to studying the mechanics of development led to some outstanding achievements, the most prominent being the discovery of the phenomenon of embryonal induction by Hans Spemann.

However, the phenomena of harmonic embryonal regulation discovered by Driesch did not conform to the principle of strict causal connections. Indeed, after extraction of some embryonal material (parts B1, C1, shown removed in Figure 1, II), the final structures B4 and C4 are formed nonetheless, although the mature embryo is correspondingly smaller. In contrast, the addition of redundant material (double portions of B1 and C1, in Figure 1, III) did not lead to doubling of final B4 and C4; and perturbation of the embryonal material did not prevent the development of the final mature embryo (Figure 1, IV). The conclusion was that the embryo's development cannot be resolved fully into a network of separate cause-and-effect connections, but that the embryo as a whole is responsible for the final result.

Thus, Gurwitsch turned away from the preformist causal-analytical conception of developmental mechanics, and adopted the vitalist conception of the whole as a factor organizing the "normal" embryogenesis as well as harmonic regulation. However, while Driesch himself refrained from further research on the whole, which he associated with the agnostic *entelechia,* not available to rational analysis, for Gurwitsch this was just a starting point for the development of his own origi-

nal path of research. This path considered the whole as an object for scientific analysis, that is, as a "working" principle.

Elaboration of Quantitative (Statistical) Criteria Confirming the Influence of the Whole on Its Elements

Although Driesch's experiments seemed to have substantially shaken the conception of unequivocal causal connections, Gurwitsch considered it necessary to show the applicability of Driesch's conception as a "working principle" for the analysis of a normal development cycle, without drastic experimental interference. In his 1910 paper "Über Determination, Normierung und Zufall in der Ontogenese" (On Determination, Regulation, and Contingency in Ontogenesis), Gurwitsch made a unique analysis of the behavior of elements (cells) during the development of geometrically exact and symmetric forms, such as a sea urchin gastrula, the crystalline lens and cornea of a chick embryo, and an onion root. The question was, whether the exact geometrical, definitive "macroform" of the embryo (or the organs) is associated with (and the result of) the correspondingly strict and coordinated behavior of the elements. The experiment ("Naturexperiment" according to Gurwitsch), consisted in the calculation of the numbers of mitoses in both halves of the macroforms, and the comparison of the empirical curves with the theoretical Gaussian curve of normal distribution.

The results showed different kinds of distributions in the empirical curves. Only in the case of the sea urchin gastrula was the distribution "subnormal," that is, the empirical deviation (difference between the numbers of mitoses in the halves) was less than the standard deviation of the normal (Gaussian) distribution. In the other cases, the empirical distribution of the number of mitoses was either normal or "supranormal." However, there was no case of mirror symmetry between single mitoses synchronously occurring in both halves. The case of the subnormal distribution of mitoses was designated by Gurwitsch as "determination," which means that there is an individual causal interaction between the symmetric mitoses. In the cases of the subnormal distribution of "microprocesses" (mitoses) in the developing macroform, one should accept the presence of immediate causal connections between the microprocesses. In contrast, both normal and supranormal distributions of microprocesses, designated by Gurwitsch as "normating" (from the German *Normierung* [usually translated as standardization or regulation—eds.]) show the absence of the immediate causal connections between the microprocesses. Instead, the microprocesses are subordinated to a "single normating factor," which is common to all. Thus did Gurwitsch establish the principle of the subordination of "equipotential" elements to a common invariant "normating" factor, as an alternative to the principle of immediate causal interactions between specifically "predestined" elements.

The actual influence of the "normating" factor on the elements is associated with their localization within the developing macroform. This notion became a prototype of Gurwitsch's field principle. In his paper "Heredity As a Realization Process" (1912), Gurwitsch suggested criteria for the equipotential elements being under the influence of the whole, which is expressed as a field factor. These criteria are as follows: (a) the dependence of the elements on their location within the whole (their fate, according to Driesch, which can be expressed either by their movement and/or by their differentiation) is fairly certain and mathematically simple; (b) the successive putting in order of the arrangement of the elements during the embryo's development (the whole), from apparent disorderly dispersion to a more and more regular spatial distribution; (c) "the including," the whole (a geometrically regular contour of the macroform shape), is more precise than the "included" (the distribution of the elements constituting this contour at the microlevel). The meaning of this is that the geometrical exactness of the macroshape is not constituted by the exactly shaped and correspondingly arranged "included" elements (like that in puzzle mosaic constructions, where each piece is precisely localized). On the contrary, the whole itself acts as an organizing factor, providing a particular arrangement of the elements whose individual microshapes, not being predetermined, are adapted to (dictated by) the macroshape contour at each geometrically specific point.

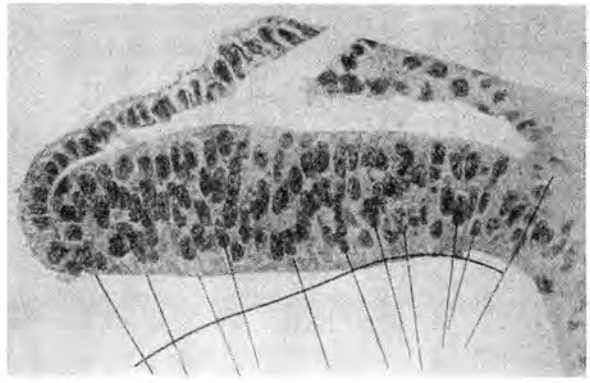


Figure 2
ORIENTATION OF CELL AXES IN THE BRAIN VESICLE OF A SHARK

The orientation of the axes of cell nuclei in the mitotic zone of the shark's brain vesicle has prognostic significance.

Source: A.G. Gurwitsch 1914

Thus, by elaborating criteria of the potential influence of the whole as a factor on the elements' behavior during normal embryogenesis, Gurwitsch for the first time attempted to make the concept of the whole a working concept, and hence, converted it from *entelechia,* which was declared unknowable, to a working principle available to strict scientific analysis.

Construction of Embryonal Morphogenic Fields

According to Gurwitsch's analysis, therefore, the whole subordinates the elements to a single common invariant field factor. Indeed, such a conception makes sense only when the dependence of elements on the field is invariant within a sufficiently lengthy period of the embryo's development.

In his paper, "The Mechanism of Form Inheritance" (1914), Gurwitsch suggested an invariant law explaining the movements of embryonal cells over a long period of development. The work was based on a histo-embryological study of the movements of epithelial cells of the developing shark brain. It

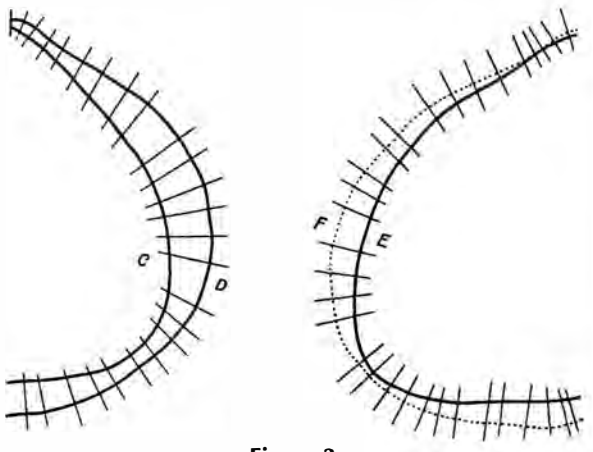


Figure 3
THEORETICAL CONSTRUCTION COMPARED WITH THE OBSERVED FORM OF THE BRAIN VESICLE
Agreement of the predicted (E→F) with the observed (C→D).

Source: A.G. Gurwitsch 1914

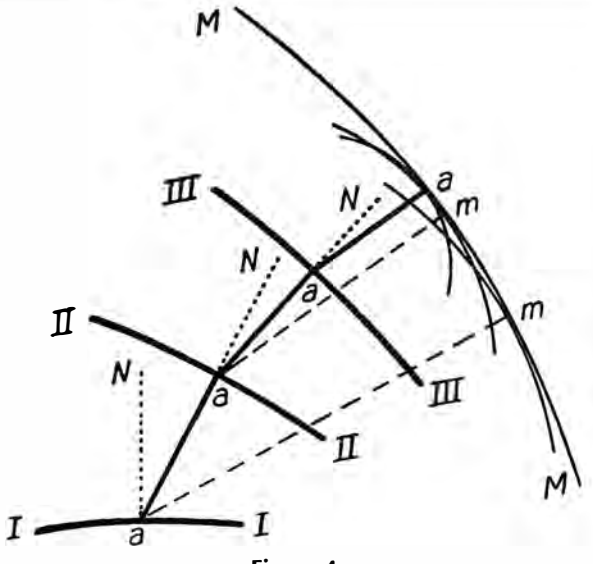


Figure 4
TRAJECTORY OF AN EPITHELIAL CELL (NUCLEUS) UNDER THE INFLUENCE OF THE DYNAMICALLY PREFORMED MORPHA
During the morphogenic process, the moving cells are oriented as if attracted by a "surface of force," designated by Gurwitsch as a "dynamically preformed morpha" (DPM). Contours of successive stages in the development of an epithelial layer are shown in I, II, and III, with N representing perpendiculars to the momentary surface of the layer, am the shortest distance from the base of the perpendiculars to the DPM surface, and aaaa the actual cell (nucleus) trajectory, the bisector between N and am.

Source: A.G. Gurwitsch 1914

was the first embryological study in which the movement of the epithelial cells within the neural layer was found. The crucial discovery was that at each moment of the development of the embryo's cerebral vesicle, the long axes of cells in the internal layer of the neural epithelium were not oriented perpendicularly to the layer surface, but at an angle of 15 to 20 degrees. Such orientation turned out to have a prognostic significance: A curve constructed normal to the cell axes at a certain developmental stage, will coincide with the actual shape of the cerebral vesicle at a later stage of development (Figures 2, 3, 4). Gurwitsch compares such a prognostic orientation with the turning of a ship's helm which precedes the turning of the ship itself.

On the basis of these data, Gurwitsch formulated the following abstract invariant regulation. During the morphogenic process, the moving cells are oriented as if they are attracted by a "surface of force" which was designated by Gurwitsch as "dynamically preformed morpha" (DPM). According to this concept, at each moment, the cells' long axes are oriented along the bisector between a perpendicular to the actual surface of the developing layer, and that of the DPM (Figure 4). If, in the limits of this construction, one analyzed a set of the successive shapes of the developing layer, one could see that some points of the layer are at a minimal distance from the DPM surface, while others are at a maximal distance (Figure 5). According to the DPM conception, the cells in the former area are under a stronger attracting influence of the DPM than the latter. Correspondingly, the actual microscopic picture shows strong polarization of the cell nuclei in the areas close to the DPM surface, and their disorderly arrangement in areas remote from the DPM surface. This polarization is measured by calculating the degree of dispersion of the orientation of cell axes around some mean position (perpendicular to the layer) in both areas (Figure 6), and in some cases strong polarization (intensive attraction by the DPM) and dispersion are evident without special calculations (Figure 7).

Thus, the "invariant law" describing the behavior (movements) of the cells during a relatively long period of development was demonstrated. However, the law was based on only one specific object, its mathematical expression was too complicated and close to a simple interpolation, and its teleological inclination was evident, because the law's action was associated with the DPM, which did not exist at the moment of its action.

Gurwitsch elaborated on the field principle in his next paper, "A Concept of Embryonal Fields" (1922). Logically similar invariant constructions were made for the case of the morphogenesis of the floscule of the chamomile plant (Matricaria chamomilla), and the hats (fruit bodies) of two mushroom species.

The mature form of the chamomile floscule has the geometrically regular shape of a stereometric paraboloid. However, at earlier stages, the developing floscule shape is not so regular, and only gradually reaches the definitive paraboloid form which can be considered a kind of "dynamically preformed morpha." The behavior of the components of the regular paraboloid, which are single flowers consisting of proximal receptacles and distal corollas, is quite remarkable. Evidently, the lower flowers of the floscule ("the included") must grow faster in order to allow the formation of the regular

paraboloid shape of the floscule as a whole ("the including"). The growth of each single flower results from the growth of the parts of both its corolla and receptacle. It was found that the accretions to each part are not strictly determined, and can be quite different, but that they are coordinated in such a way that the resulting growth velocity of the flower as a whole is strictly regular, securing the paraboloid shape. Some individual variations in the flower's growth velocity lead to compensatory bending of the flower's axes, and the stretching of their parts (Figure 8, 5a, 5b). Gurwitsch's invariant law is expressed by the DPM paraboloid force surface, now designated a "field," which attracts the elements (single flowers) along radial trajectories so that the direction and accretion values of each individual flower are the function of its localization in the field.

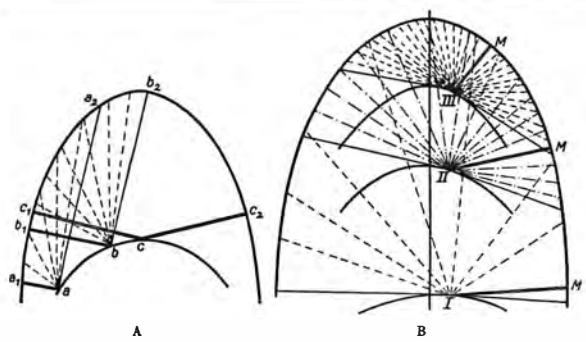


Figure 5
INFLUENCE OF THE DPM ON VARIOUS POINTS OF THE SURFACE LAYER

The initial stage of development is shown in A, and the following phases, I, II, and III, are shown in B. Various points on the surface of the epithelial layer are designated a, b, and c. Various points on the DPM surface are identified as a1, b1, c1, a2, b2, and c2. The direction of maximal influence of the DPM is indicated at each stage by M.

In the initial stage, point a has one predominant M direction (a→a1), while c shows two opposed M directions (c→c1 and c→c2). In the following stages, I→II→III, the observed point eventually comes under a single M influence: the distance III→M is significantly shorter than any other radial line from III.

Source: A.G. Gurwitsch 1914

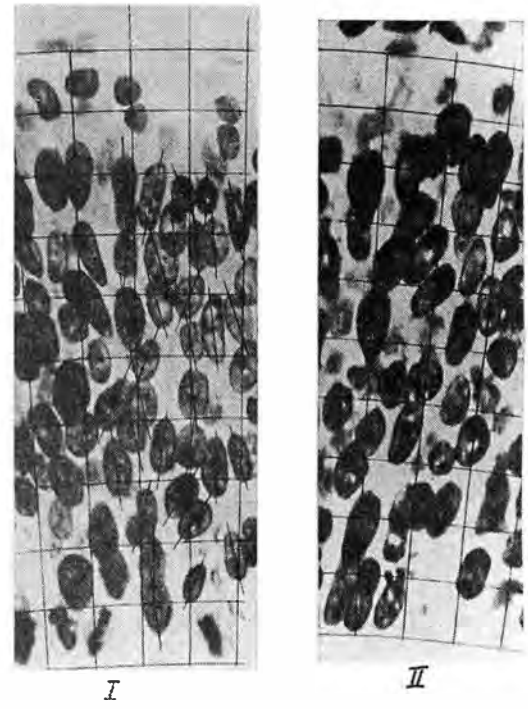


Figure 6
DISPERSION OF CELL AXIS ORIENTATIONS IN THE EPITHELIAL LAYER OF THE BRAIN VESICLE

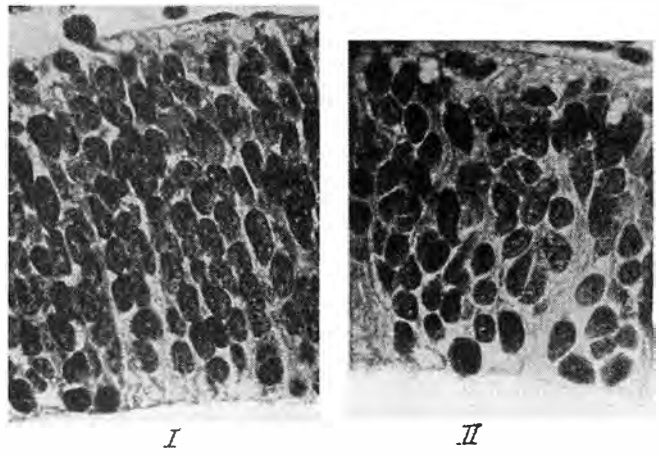
Image I shows an area distant from the DPM surface and displays maximal dispersion of the axes of the cell nuclei from lines normal to the surface of the layer. Near the DPM (Image II), the dispersion is minimal.

Source: A.G. Gurwitsch 1914

Figure 7
POLARIZATION AND DISPERSION OF CELL AXES AS A FUNCTION OF INFLUENCE OF THE DPM

Images I and II show two regions of the epithelial layer that differ in their distance from the DPM surface and correspond to the different coordinates in Figure 5. Image I corresponds to point a (Figure 5A—minimal distance from the DPM in the direction a→a1). The polarization and slanting arrangement of the cell nucleus axes, oriented in the M direction (maximal influence of the DPM), is clearly recognizable. Image II corresponds to point c (Figure 5A—equal distance of the point from the opposite sides of the DPM surface c→c1→c2) and shows a maximal dispersion of axes.

Source: A.G. Gurwitsch 1914



The morphogenesis of two kinds of mushroom is described by another kind of field structure. At the early stage, the developing fruit body of a gymnocarpus mushroom (Marasmius sp.) consists of a disorderly bundle of hyphae whose edges define the correspondingly loose and indefinite contours of the body. As it develops, the edges of the hyphae are "brushed up" and, accordingly, the contours become more geometrically regular (Figure 9).

In the case of an angiocarpus mushroom, the developing fruit body at the early stage also consists of a disorderly plexus of hyphae. As it develops, a geometrically regular arched line looms, located not upon the upper edges of the hyphae, as in the case of the Marasmius, but below the edges of the hyphae. The next developmental step displays loosening, and finally, falling off of the edges of the hyphae that are above the contour to be formed (Figure 10).

The morphogenic field in this case is described by the following structure: If the plane projection of the mushroom's hat shape is considered, there are two point field sources located at the edges of the definitive form of the hat body (Figure 11). These are the sources of forces, whether attractive or repulsive, which decrease in proportion to distance and are summed up according to the parallelogram rules of force composition. Hence, a set of equipotential surfaces can be obtained, one of them corresponding to the major value of the vertical force component (Figure 11, dotted line). This arched line corresponds to the distal surface of the Marasmius mushroom hat, along which the edges of the hyphae are "brushed up." It also corresponds to the barrier line above which the edges of the hyphae fall away in the angiocarpus mushroom. This field construction is quite different from the concept of the DPM used in the case of the shark brain vesicles and the chamomile floscule morphogenesis, because now the definitive forms of the mushrooms' hats do not correspond to DPM attracting-force surfaces, but are the equipotential field surfaces originating from point sources. Another important aspect is that this kind of field does not have the teleological coloration of the previous DPM constructions and can be considered a causal factor.

The next important step in the construction of the morphogenic field was made by A.W. Anikin, in studies under the direct guidance of Gurwitsch (A.W. Anikin 1929). These stud-

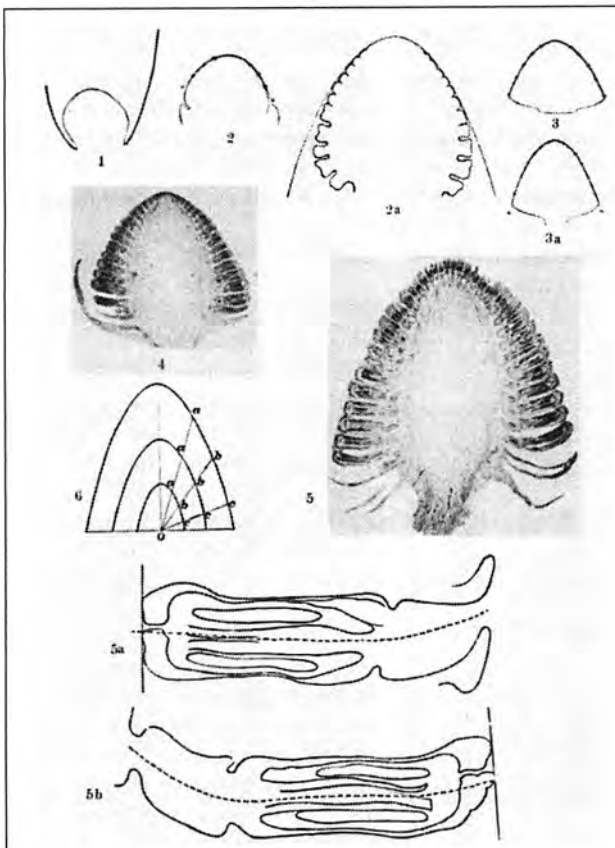


Figure 8
MORPHOGENESIS OF THE CHAMOMILE FLOSCULE

Drawings 1, 2, 2a, 3, and 3a show contours of the chamomile floscule in successive stages of development, with increasingly precise geometrization of the form toward a paraboloid: the form is partially (2, 2a) and then fully (3, 3a) inscribable in a parabola.

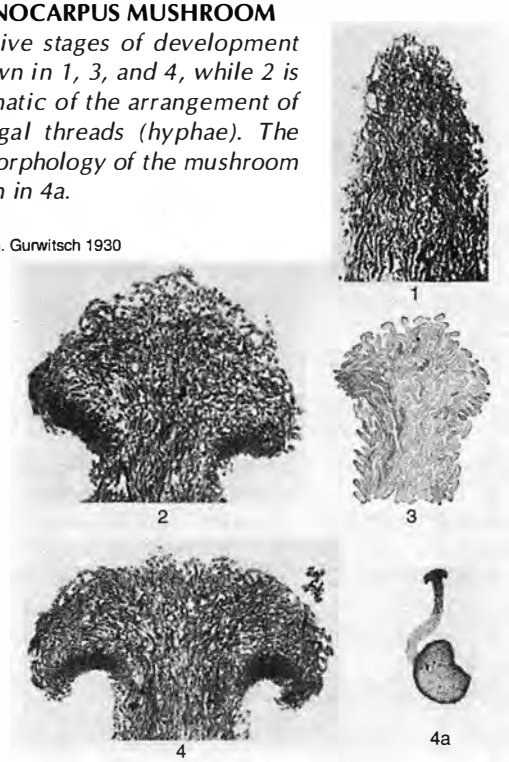
Images 4 and 5 show sagittal cuts through the structure at two successive stages of development. The mature floscule (5) is shown with morphologically different individual flowers on opposite sides; 5a shows the contour of a basal flower from the left side of the "normal" shape, and 5b is a flower from the right side with "distorted" shape. Both look like they have been stretched to the surface of the circumscribing paraboloid; by reaching it, they contribute to the geometrical preciseness of the whole floscule. A geometric scheme of the development process is shown in 6.

Source: A.G. Gurwitsch 1930

Figure 9
MORPHOGENESIS OF THE GYMNOCARPUS MUSHROOM

Successive stages of development are shown in 1, 3, and 4, while 2 is a schematic of the arrangement of the fungal threads (hyphae). The gross morphology of the mushroom is shown in 4a.

Source: A.G. Gurwitsch 1930



ies were an analysis of changes in the shape of nuclei of mesenchymal cells during the development of the triton phalanx cartilage. In the transverse section of the phalanx, various shapes of the nuclei are distributed with a certain regularity. In the center of the section, the nuclei are of round shape, which changes to an increasingly curved one (bean shape), depending on distance from the center. However, beyond a certain critical distance toward the periphery, the shape again becomes round. The range of forms of the nucleus can be described by a law which is a function of location relative to the phalanx axis of symmetry. The law is based on the idea that the geometrical center of the section transverse to the axis, is a point source of a repulsive isotropic field, acting on each point of the surface of the nucleus. Insofar as mitoses occur mainly along the axis, and the nuclei move centrifugally, the momentary velocity *(v)* of each point of the nucleus is inversely proportional to the distance of the point from the source, and can be expressed by the differential equation:

$$\mathrm{d}R = \frac{K}{\mathrm{d}T} = \frac{V}{R},$$

where R is, in general, coordinates of the given point and, in particular, the point's distance from the field source; t is time, and K is a coefficient of proportionality. Integration of this equation gives an expression combining the distance traversed by the point and the time of travel. If the initial distance between the point and field source is R, and the point moves for an additional segment r in the centrifugal direction, this will take time t', which is associated with R and r by:

$$2Kt = r^2 + 2Rr.$$

On the basis of this equation, a graph can be constructed of the dependence of the velocity of each point of the nucleus surface on its distance from the center, and hence it is possible to infer and construct theoretical shapes of the nuclei, as a function of their distance from the point source of the field (Figure 12). These theoretical shapes are highly similar to the actual morphological appearance of the nuclei in histological preparations (Figure 13). The deduced formula of postulated field action describes very well the observed phenomenon in the morphogenesis of the triton phalanx. There is a remarkable

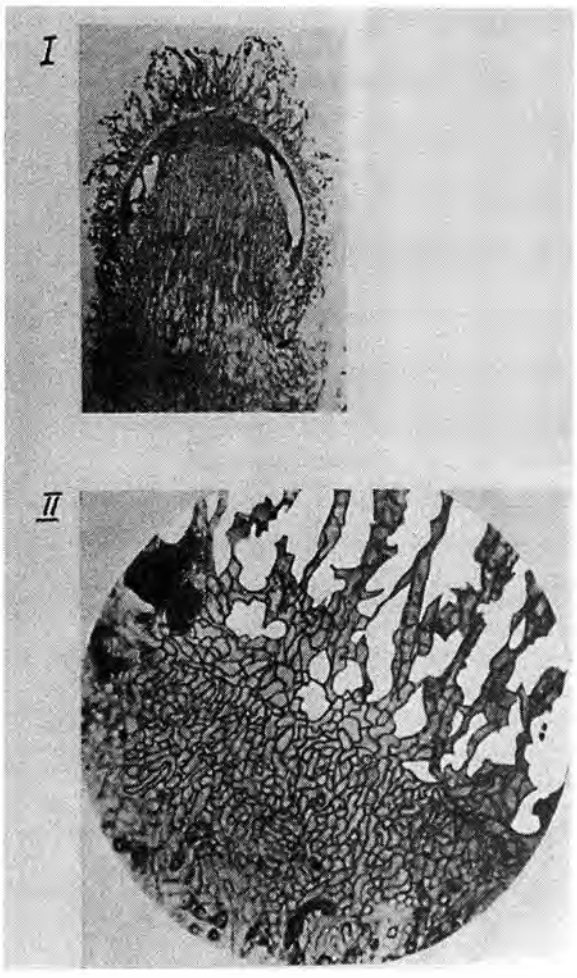


Figure 10
MORPHOGENESIS OF THE ANGIOCARPUS MUSHROOM

The developing fruit body at the early stage again consists of a disorderly plexus of hyphae. As it develops, a geometrically regular arched line looms, located not upon the upper edges of the hyphae, as in the case of the Marasmius (see Figure 9), but below the edges of the hyphae. The next developmental step displays loosening, and finally, falling off of the edges of the hyphae that are above the contour to be formed. Low magnification (I) and stronger magnification (II).

Source: A.G. Gurwitsch 193

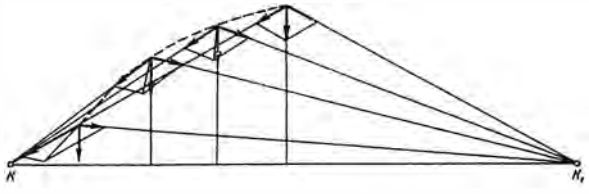


Figure 11
MORPHOGENIC FIELD OF THE DISTAL SURFACE OF THE MUSHROOM HAT

If the plane projection of the mushroom's hat shape is considered, there are two point field sources located at the edges of the definitive form of the hat body. These are the sources of forces, whether attractive or repulsive, which decrease in proportion to distance and are summed up according to the parallelogram rules of force composition. Hence, a set of equipotential surfaces can be obtained, one of them corresponding to the major value of the vertical force component (dotted line). This arched line corresponds to the distal surface of the Marasmius mushroom hat, along which the edges of the hyphae are "brushed up." It also corresponds to the barrier line above which the edges of the hyphae fall away in the angiocarpus mushroom.

Source: A.G. Gurwitsch 1922

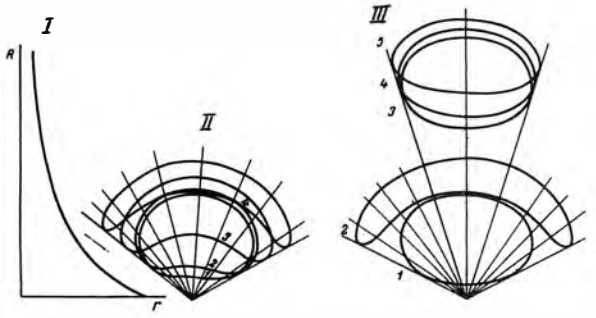


Figure 12
THE MORPHOGENIC FIELD IN THE DEVELOPMENT OF THE TRITON PHALANX CARTILAGE

Changes in the shape of cell nuclei of mesenchymal cells occur with regularity during the development of the triton phalanx cartilage. In the center of a transverse section of the phalanx, the nuclei are round, but they change to bean shape with increasing distance from the center. Beyond a certain critical distance toward the periphery, the shape again becomes round.

The distance r travelled by a point on the surface of the cell nucleus depends on the initial distance R between this point and the field source. This hyperbolic function of the second degree is shown in I. The corresponding calculated changes in the form of the nucleus, as the nucleus becomes more distant from the point field source (1→2→3→4), are shown in II. Drawing III shows changes in the nuclear shape in the central (1→2) and peripheral (3→4→5) areas of influence of the field source.

Source: A.G. Gurwitsch 1930

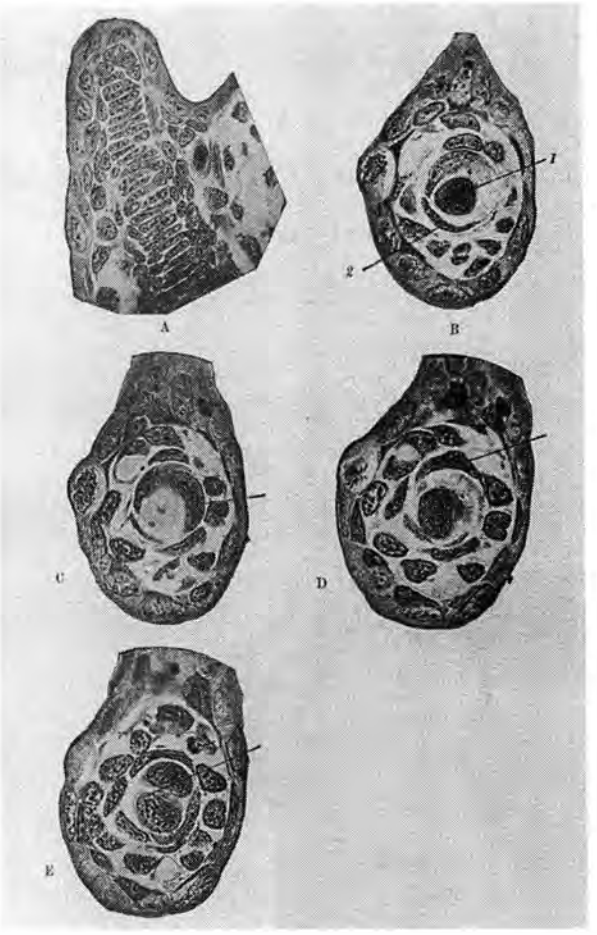


Figure 13
CHANGES IN THE SHAPE OF THE NUCLEUS ACTUALLY OBSERVED IN HISTOLOGICAL PREPARATIONS

A sagittal section is shown in A, while B, C, D, and E are transverse sections.

Source: A.G. Gurwitsch, Histologische Grundlagen der Biologie, 1930

regularity in the gradual changing of the shape of the nucleus, from round to bean-like, but then, after a further small but critical increment of distance, back again to round.

Two more studies testing the applicability of the field principle to the problem of cytodifferentiation during development were carried out, one by Lydia Felicine-Gurwitsch, Gurwitsch's wife, and the other by Gurwitsch himself.

The object of the former study, titled "Application of the Field Principle for Analysis of the Processes of Embryonal Differentiation" (1924), was associated with the development of the amphibian retina. The main question was whether there are any components in the process of cytodifferentiation which depend on the coordinates (relative to the axes of symmetry) of the differentiating cells within the whole retina layer. Accordingly, histogenesis in the central and peripheral parts of the retina were compared. It was found that the growth of the amphibian retina proceeds by the addition to the retina layer of new cells from the marginal mitotic zones. These young cells are much smaller than the mature rod-cells to which they will be converted as a result of differentiation. Correspondingly, the cells at the central part of the retina are older and larger. Thus, maturation includes both growth and differentiation. At a certain stage of development, a wave of differentiation passes throughout the cells of the whole retina. Therefore, cells in the central part of the retina first grow, and then differentiate, while in the peripheral part, the cells first differentiate and then grow (Figure 14). Such varying relationships between rates of growth and differentiation in different cells are a function of the distance of the cell from the center of the retina (exit of the optic nerve).

While in the previous models, morphogenic field action was expressed in cell movements, changes in the shape of nuclei, and other "kinematic" effects, here the field action means directing the cell either to continue growing or to start differentiating, two processes of quite different character. In other words, in the previous models the "mechanism" of the suggested field action, either attraction or repulsion, was more immediately realized through the observed cell movements, while in the case of the differentiation of the retina, the field was seen to be a factor having a much deeper involvement in cellular structure and function.

In a second field model dealing with cytodifferentiation, Gurwitsch analyzed the process of mammalian spermatogenesis

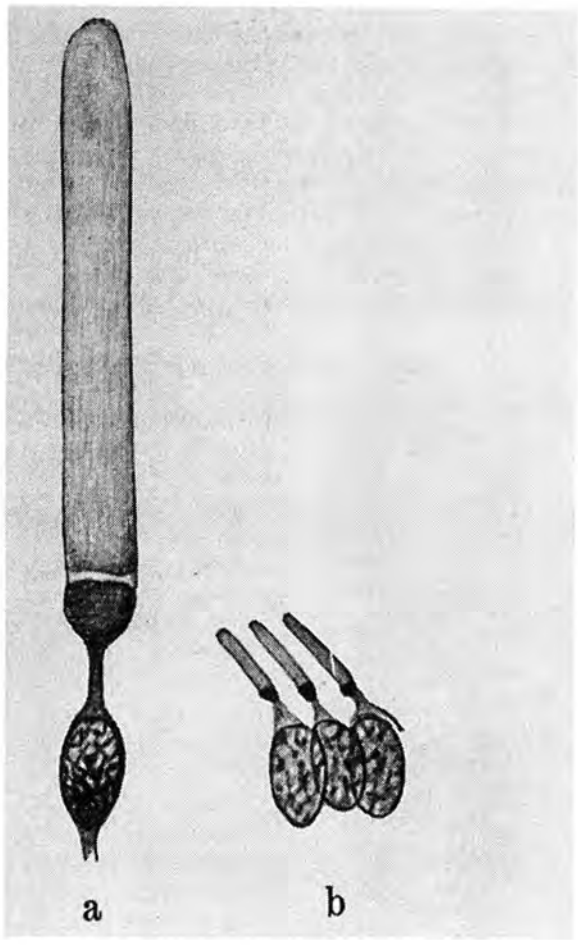


Figure 14
ROD CELLS IN THE RETINA OF A YOUNG FROG JUST AFTER METAMORPHOSIS

A rod cell from the central area of the retina is shown in a; rod cells from the periphery of the retina are represented in b (same magnification).

Source: A.G. Gurwitsch 1930

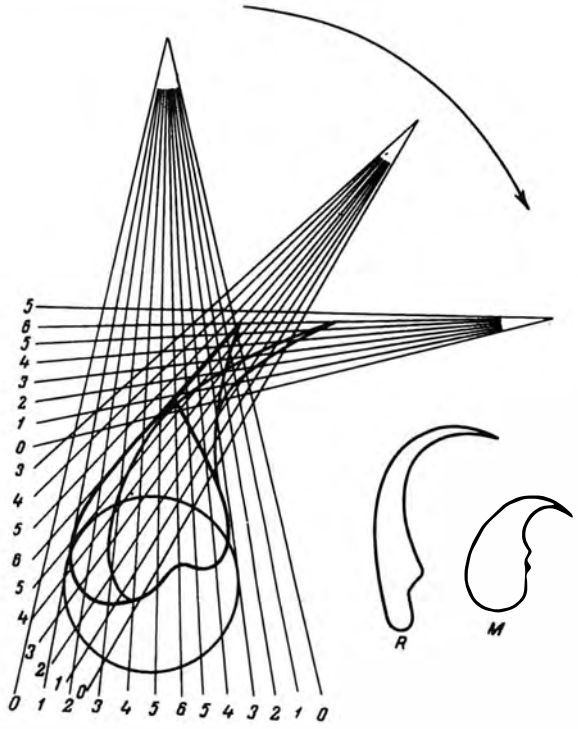


Figure 15
CONSTRUCTION OF THE MORPHOGENIC FIELD DESCRIBING THE DIFFERENTIATION OF THE HEAD OF A SPERM CELL

Gurwitsch's model is based on the idea that the developing sperm cell is under the influence of some external field whose point source rotates around the cell. The drawing shows three successive stages of differentiation of a sperm cell. Fully formed rat and mouse sperm cells are shown in R and M.

Source: A.G. Gurwitsch 1927

(1927). Differentiation during spermatogenesis combines both drastic changes in general cell morphology and complicated intracellular movements of the cell organelles, such as centrioles, Golgi apparatus, and so on. Both changes in cell morphology and the displacement of organelles are perfectly described by Gurwitsch's model, which is based on the idea that the developing sperm is under the influence of some external field whose point source rotates around the cell (Figure 15).

The models based on Gurwitsch's primary conception of an embryonal morphogenic field, present a mixed collection of abstract constructions. Indeed, the model field can be either attractive (the dynamically preformed morpha of cerebral vesicles and the chamomile floscule), or repulsive (Triton phalanx). Also, its descriptive capacity can work independently, whether attraction or repulsion is ascribed to it (mushroom hats), or the field surface is of paraboloidal or other regular form. It can originate from point sources (Triton phalanx, sperm, amphibian retina), or it can be vectoral (mushroom hats). However, in spite of their mixed character, these models are united by the same fundamental principle: A single invariant law describes the development of a specific part of the embryo as a complete macroform during a relatively long period.

However, in spite of the elegance and descriptive capacity of the field models, Gurwitsch himself realized the shortcomings of his primary field conception, emphasizing that this approach was only the first step toward its further development.

First, although the field models are effective in their ability to describe events during a sufficiently long developmental period, none of them can serve as an invariant principle for the whole ontogenetic cycle. For example, a particular formula of the "dynamically preformed morpha" can fairly well describe the development of the shark's cerebral vesicles, but it is not fit for the description of any further development of the same species. In other words, the model may be suitable for a period of development from A to B, but the next period from B to C will need another model. Second, the objects analyzed by the models are rather artificially and arbitrarily delimited from the

whole embryo. Thus, the only, though highly so, valuable principle of these models was the invariant postulate, and the next intention of Gurwitsch was to use it for an adequate description of intracellular processes.

Molecular Prerequisites of the Field Theory: Use of Basic Principles of the Field Theory For Processes Occurring at Molecular Level

From the beginning of his scientific activity, Gurwitsch showed interest in the biological processes occurring at the molecular level, which was exceptional for a histologist at that time. His first work in this direction—which can be considered one of the first studies of molecular biology—concerned regulational phenomena in the protoplasm of amphibian and echinoderm eggs, revealed by means of the centrifugation method, applied for the first time to living things (A.G. Gurwitsch 1904, 1905, 1908). The main finding was that, although all the contents of the eggs were reshuffled by centrifugation, and all the visible structures destroyed, the first stages of development, cleavage and blastula formation, proceeded. The visible structures in the cytoplasm were usually restored, but often development proceeded even without such restoration. Gurwitsch's conclusion was that when destruction of the structure of the cytoplasm is followed by its restoration, it is re-created from certain amorphous (invisible) materials, which are carriers of (are responsible for) living expressions. Gurwitsch proposed that, in the case of reversible perturbations of the initial intracellular molecular organization, certain "dynamic conditions" in the cytoplasm responsible for the organizational specificity remain undisturbed, and restore the damaged molecular organization using deliberately different material (molecules).

From archives of L. Beloussov

The Gurwitsch laboratory at Simferopol (1923-1924). Gurwitsch is first row, second from left; his wife is third from left.

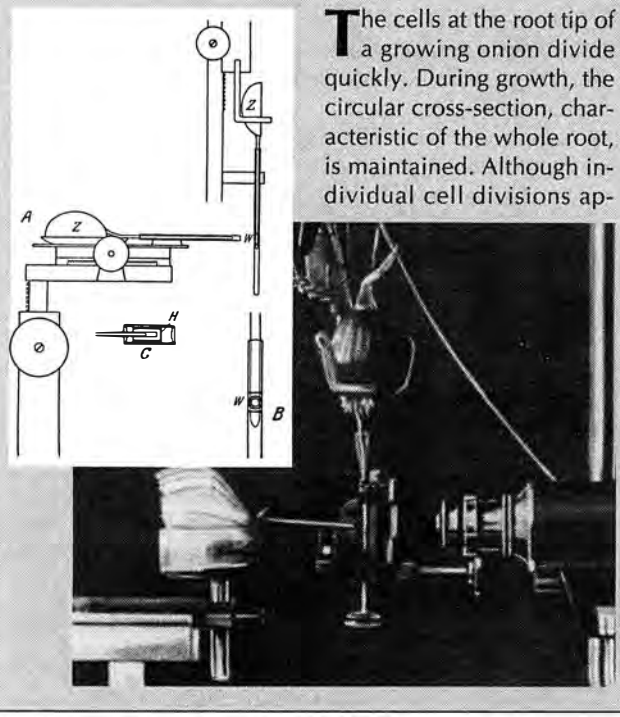
Such "interchangeability" of the molecules participating in the morphogenic processes is the expression of the same phenomenon of equipotentiality described by Driesch, now observed at the molecular level. The specificity of the observed processes (in spite of the destruction of the structures normally participating in them) realized through the involvement of other molecules, impelled Gurwitsch to designate the cytoplasm as the "structured process" which underlay his "physiological theory of protoplasm." The application of the regulational principle of Driesch (harmonic regulation) to the molecular level meant that a single cell should be considered as the whole. Accordingly, the notion of equipotentiality when applied to the molecular level was designated by Gurwitsch as "polyreactivity" (A.G. Gurwitsch 1944). Essentially, this means that there is no predetermination of intracellular compartments: The subcellular entities behave according to their coordinates in the whole cell which, hence, presents a dynamic network (in correspondence with the coordinate network), which determines the fate of the molecules locally involved ("structural process").

These views were supported by experiments in which the application of cooling, starvation, and narcosis to fertilized eggs caused chaotic movements of intracellular organelles, such as centrosomes, mitotic spindles, and so on (A.G. Gurwitsch 1944). Gurwitsch concluded that the harmonic movements observed in a normal cell are caused by a certain factor related to the cell as a whole, and that this factor is not destroyed or inactivated by the centrifugation method, which destroys the visible intracellular structures. Therefore, space-time connections between separate intracellular structures or processes are not the result of any properties of the structures themselves. In general, the experimental factors causing such chaotic movements of the intracellular organelles, such as starvation, cooling, and narcosis, directly or indirectly decrease the intensity of energy metabolism. For Gurwitsch, this was the starting point for a crucial leap of thought, that the metabolic energy is necessary for the maintenance of this intracellular invisible structurality. Further development of this idea led to the conception of two distinct kinds of molecular associations in living systems.

The associations of the first kind are stable molecular formations constituting visible and invisible structures, in which the molecules are bound together by means of ordinary chemical bonds: covalent, ionic, hydrogen, and Van der Waalsian. In order to destroy these structures, external energy must be applied to break the bonds.

The associations of the second type are unstable molecular constellations, in which the molecules are not connected to each other by any of the above-mentioned bonds, but their association within the constellation is supported by a continuous influx of energy. This means that if for any reason the energy influx ceases, the constellations immediately dissociate. Such labile molecular associations, within which the molecules are not bound by any known chemical bonds, and whose existence depends on a continuous influx of metabolic energy, was designated by Gurwitsch as "unbalanced molecular constellations." The word "unbalanced" is perhaps an in-

Gurwitsch's Famous 'Onion Experiment'



The cells at the root tip of a growing onion divide quickly. During growth, the circular cross-section, characteristic of the whole root, is maintained. Although individual cell divisions appear to occur in an unordered, even random distribution, the number of divisions in all directions from the axis must nevertheless be approximately equal. The root would otherwise not have a cylindrical form.

Gurwitsch supposed that at least some of the cells must be emitting light that regulated the rate of division of the other cells; he proved it by means of the experimental setup shown here. The roots (W) of two onions (Z) were positioned perpendicularly, so that the tip of one root pointed to one side of the other root. He then examined under the microscope the second root, at the site facing the tip of the first root. He was able to establish a statistically significant increase in cell divisions there, compared to the opposite, "unirradiated" side. This effect disappeared when he placed a thin piece of window glass between the two roots, and reappeared when he replaced it with quartz glass! That meant that ordinary glass is opaque for mitogenetic radiation, while quartz glass is translucent. Hence electromagnetic radiation must be operative, and ultraviolet light in particular, since it passes through quartz, but is stopped by window glass.

Source: A.G. Gurwitsch, *Das Problem der Zellteilung* (The Problem of Cell Division), 1926

adequate English translation of a Russian equivalent, which was first introduced and widely used by Gurwitsch, who had no opportunity to publish the material in English.

Similar ideas concerning the unbalanced state of the living system were developed independently by E. Bauer (1935), who considered the general intrinsic property of the protein molecules of the living system to be a "steady unbalanced state," which is expressed in their deformations. Accordingly, the metabolic energy is transformed into a certain "structural energy" in deformed (structurally altered) protein molecules, which is utilized for the realization of functions of the organism. An adequate experimental examination of this hypothesis was seen by Bauer as an attempt to reveal this structural energy, which is released as the living system dies.

Gurwitsch often indicated the closeness of his and Bauer's views on the unbalanced state of the living system, and emphasized Bauer's priority in the general elaboration of this conception. However, there was an important difference in the representation of a substrate for the realization of the principle of the unbalanced state in living systems. According to Bauer, the state relates to the internal (deformed) structure of the protein molecules themselves, while Gurwitsch, on the basis of strong evidence, came to the conclusion that not only separate molecules, but actually the labile molecular constellations, are in the unbalanced state, forming the entire molecular continuum throughout the cell.

The evidence Gurwitsch used to come to such a conclusion related to the phenomenon of degradational mitogenetic radiation (A.G. and L.D. Gurwitsch 1937a; A.G. Gurwitsch 1937b). Unbalanced constellations need a continuous influx of metabolic energy for their existence, and at any moment possess the required amount of accumulated potential energy (position energy). Moreover, the involvement of a high number of protein molecules in a constellation, and the relationship to the entire continuum create the conditions for the formation of common energetic levels, permitting the migration of common energy within the constellations, with the possibility of its summation at certain points of the continuum. Certainly, the area of such energy migration had to be within supra-molecular distances. These considerations shaped the experimental approaches aimed to reveal the accumulated potential energy.

The first approach, realized by Anna A. Gurwitsch (1947), consisted of experiments on protein solutions in which the protein molecules were oriented by applying physical factors, such as a constant flow of the solution, or a weak electric field, or a strong magnetic field. In the first two cases, a so-called secondary mitogenetic radiation was detected from both the flowing protein solution and the solution under the influence of the electric field. The emission of secondary mitogenetic radiation is known to be a consequence of energy migration along oriented molecules (A.G. Gurwitsch 1932, 1944; A.G. and L.D. Gurwitsch 1931, 1945, 1948). The protein solutions in the experiments using the magnetic field were then exposed to infrared radiation. This resulted in an emission of mitogenetic radiation from the solution. This can be explained by the fact that the infrared energy brought to the protein solution was shifted up to the ultraviolet level (the mitogenetic radiation). The general suggestion from these experiments was that the above-mentioned physical factors caused a spatial orientation of the protein molecules in solution, leading to the formation of common energetic levels, providing energy migration and summation.

The second approach was associated with the problem stated first by E. Bauer (1935) and then by Gurwitsch (1937b), of revealing the energy spent for the support of the unbalanced state of the living system. This problem was brilliantly addressed via the discovery of the phenomenon of degradational mitogenetic radiation (A.G. Gurwitsch 1937a, 1937b). The difference between Bauer's point of view (the unstable state relates to individual protein molecules, and the metabolic energy is expended for their deformation), and that of Gurwitsch (the unbalanced state relates to the molecular constellations and the metabolic energy is expended for their current support), determined the experimental design.

It was suggested that this hypothetical energy might be captured in the form of mitogenetic radiation. According to Gurwitsch's conception, the release of the energy accumulated in the unbalanced molecular constellations can be precipitated either by stopping the influx of metabolic energy (followed by a collapse of the unbalanced constellations, with the subsequent release of the potential energy), or by "mechanical" destruction of the constellations (followed by the destruction of the common energetic levels, with subsequent release of the potential energy). Such a combination of "metabolic" and "mechanical" approaches is not applicable to Bauer's conception, which is compatible only with the former one.

The results strongly confirmed Gurwitsch's conception. All of the animal and plant objects studied displayed a short burst of mitogenetic radiation in the case of both metabolic (sharp cooling or light narcosis), and mechanical degrading factors (centrifugation or weak alternating current). Importantly, if any of the degrading factors was immediately followed by any other, it did not cause additional mitogenetic radiation. This means that all the degrading factors used in the experiments had the same target: unbalanced molecular constellations. If the constellations were already destroyed by any of the above factors, repeated application of the factor would have no effect. The degrading action of the factors used was fully reversible: After the cessation of the factors' action, a full physiological restoration of the unbalanced state was observed. Gurwitsch's conclusion was that the unbalanced state of the intracellular molecular substrate was associated with the protein constellations, rather than with individual protein molecules.

The influx of metabolic energy is an absolute condition for the existence of the unbalanced molecular constellations. Their existence is organized by a certain dynamic factor whose action, although connected with a continuous utilization of metabolic energy, is quite independent. Since precisely this factor determines the specific orientation of the protein molecules within the constellation, and the orientation is connected with the specific spatial arrangement of the protein molecules relative to certain coordinates, this dynamic factor can be defined as a field factor. Essentially, the action of the "orienting" field factor should be expressed as limitations it imposes on the free chaotic movements of the molecules. Hence, the action of the field factor is expressed in a certain vectorization of the chaotic movement of the protein molecules.

This was the basis for the new general conception based on the same principles, which could now combine the events occurring at all three levels of biological organization: organismal, cellular, and molecular. The first drafts of the new conception of the vectorial biological field were outlined by Gurwitsch in autumn 1941, in besieged Leningrad, and the completed theory was published in 1944 in Moscow, and then in 1947 in Leyden.

To be continued

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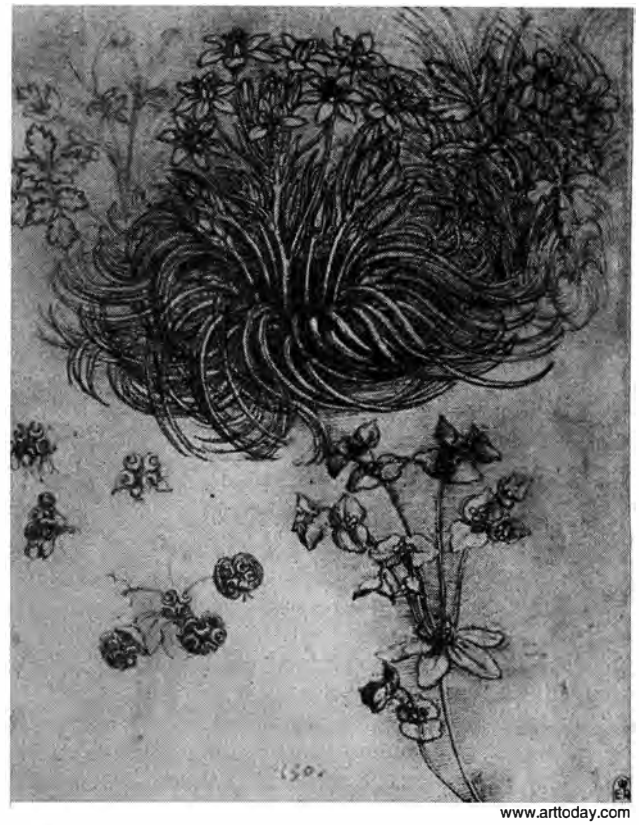
Remarks on Gurwitsch's Method

by Lyndon H. LaRouche, Jr.

An economist comments on the importance of Gurwitsch's method for physical economy, in particular, the spread of pandemics like AIDS.



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"Modern science has known, since the collaboration of Luca Pacioli and Leonardo da Vinci, that healthy living processes are characterized by a kind of harmonic ordering." Here, Leonardo's star-of-Bethlehem and other plants.

I have just read a review of Gurwitsch's work presented by one of the great biologist's former students. Gurwitsch's method has striking resemblances to the notion of living processes which I developed as a criticism of Mathematical Biophysics of Chicago's Nicholas Rashevsky, at the close of the 1940s, a criticism which aided me greatly in effecting my discoveries in economic science.

This is, I think, no mere coincidence; at the beginning of the present century, the Pasteur Institute exerted important influence on certain leading circles of Russian science, both in biology and the nuclear physics of fission. The case of Academician Vernadsky is exemplary. Also, although my friends and I have so far failed to uncover the relevant aspects of the Pasteur Institute's work, some associated with that Institute showed variously the direct and implicit influence of Bernhard Riemann's method, in their approaches to biological and biogeochemical processes. My own work has also been influenced very strongly by Bernhard Riemann, notably in treating the processes of social reproduction (Leibnizian physical economy) as coherent with the principles otherwise characteristic of living processes.

What Is Life?

Despite the recent hegemony of molecular biology, modern science has known, since the collaboration of Luca Pacioli and Leonardo de Vinci, that healthy living processes are characterized by a kind of harmonic ordering, consistent with the derivation of Kepler's astrophysical laws coherent with the construction of the circle's Golden Section, a construction cohering with the uniqueness of the five Platonic solids within the ordinary discrete-manifold space of faith in naive sense-perception. It is demonstrable, that, excepting the extremes of astrophysics and microphysics, any process which exhibits these harmonic morphogenetic characteristics is either a living process or a special case of activity by a living process.

This was emphasized already in Plato's dialogues, the *Timaeus* most emphatically, but the appreciation of such harmonic orderings antedates Plato in such respects as the original design of the Athens Acropolis and the early forms of well-tempering in classical Greek music. This standpoint was revived, most notably, by Pasteur's work on optical activity of living processes. Advances in quality of spectroscopy's instruments have lately promoted the specialized form of optical biophysics known most commonly as "nonlinear spectroscopy."

The eruption of the global pandemic, AIDS, has placed a great importance on study of the spectroscopy of the mitotic processes, work in which Gurwitsch was a true pioneer. However, the practical implications are much broader, including relevance to cancer research, and studies of the diseases of aging of tissues more generally. A.G. Gurwitsch was a true pioneer in development of the optical biophysics which promises now to dominate future leading work in biology.

The standpoint in mathematical physics most appropriate to these lines of research is that of Carl Gauss, and such among his scientific heirs as Dirichlet, Weierstrauss, Riemann, and Cantor. Where the method of Pacioli, Leonardo, and Kepler, was derived from Nicholas of Cusa's rigorous treatment of isoperimetry in such locations as his *De Docta Ignorantia,* Gauss reworked the leading accomplishments of Kepler, Leibniz, et al., superseding simply isoperimetric notions of least action with a notion of conic, self-similar-spiral action as the elementary form of least action in the universe. The work on mathematical physics by Gauss, Weierstrass, and Riemann, must be examined from the vantage point of a synthetic (radically constructive) geometry, without employment of the axiomatic-deductive forms of mathematics of a (Cartesian) discrete manifold.

Carl Friedrich Gauss (1777-1855)

Bernhard Riemann (1826-1866)

This Gauss-Riemann approach accounts uniquely for the common harmonic orderings in astrophysics and living processes, and implicitly demands that the microphysical domain be treated from this same methodological standpoint. A mapping of the principal features of the microphysical domain from this standpoint is already in progress, with some experimental proofs of this already supplied. This obliges us to supplant the notions of "negentropy" associated with the standpoint in statistical mechanics characteristic of the work of Boltzmann et al., with the definition of "negentropy" first elaborated by Pacioli and Leonardo, and asserted by Kepler. The Gauss-Riemann standpoint in radically constructive physical geometry of conic self-similar-spiral least action, provides us a vastly more adequate view of this matter.

This also signifies fundamental, ontological as well as methodological flaws in the assumption in the definitions of "cybernetics," derived from Boltzmann, et al., as supplied by Norbert Wiener, et al. If the astrophysical is ordered as Gauss's reconstruction of Kepler's laws indicates, then the elementary laws of the universe are "negentropic," not "entropic" in form. Similarly, the discrete manifold is to be viewed not as ontologically elementary, but as a projection of a higher-order continuous manifold, such that ontological elementarity lies in the physical geometry of a continuum described by a Gauss-Riemann construction of the complex domain.

Such was the standpoint of my own discoveries of the early 1950s. A brief summary of key points indicates the relevance of my own work to a reading of Gurwitsch's work.

The point of departure for my discoveries was my rejection of Norbert Wiener's definition of "negentropy" in human behavior and "information" transmitted by this behavior. Like Immanuel Kant's *Critique of Judgment,* Wiener's approach insisted that true synthetic judgment (creative discovery) was accomplished by an unknowable process. Wiener went further, to insist that such synthetic judgment was nonexistent. Since the progressive evolutionary development of the biosphere exhibited a characteristically creative process of morphogenetic development, and since the increase of demographic potential of the human species exactly paralleled such evolution within the biosphere, the cause of human creative thought must be a special sort of development of the same kind of negentropic principle characteristic of living processes. That is, that the physiology of the human brain's function must provide the efficient substrate for higher manifestations of human intelligence.

In other words, mentation must not only be rooted in the mechanisms of reproduction of cells, but must be subordinated to the same, subsuming morphogenetic principles of

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EDITOR'S NOTE

LaRouche's remarks were written on March 15, 1987, when Michael Lipkind's work on on Alexander G. Gurwitsch was being discussed and edited for publication in Fusion *magazine. The delay in publishing these comments, and the Lipkind work, has a history of its own.*

On April 23, 1987, Fusion, *a publication of the nonprofit Fusion Energy Foundation, was summarily shut down and put into forced bankruptcy by a corrupt faction of the U.S. federal government, as part of their "Get LaRouche" campaign. LaRouche was a member of the foundation's board of directors. Two and one-half years later, the foundation, and two LaRouche political publications that were also put into forced bankruptcy, won a lawsuit against the federal government for the illegal shutdown, and subsequently, when the government appealed that decision, the publications won the appeal. Federal bankruptcy judge Martin V. B. Bostetter, Jr., ruled that the government had "acted in bad faith," and had perpetrated "a fraud on the court" in pursuing the forced bankruptcies.*

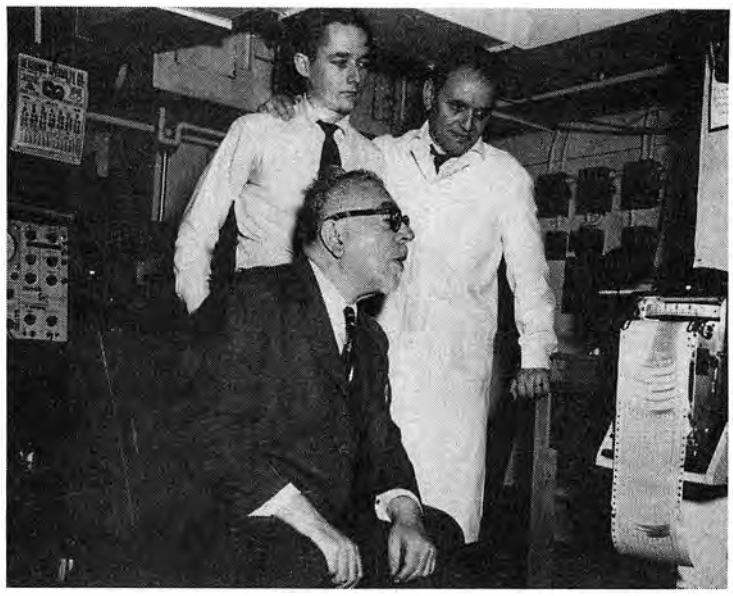
The editors of Fusion *magazine, which at its height had nearly 200,000 subscribers, founded* 21st Century Science & Technology, *to continue* Fusion's *mission, publishing the first issue in early 1988.*

The second part of LaRouche's comments will appear in the next issue, along with Part 2 of Lipkind's work.

(Riemannian) potential which delimits the cell-production processes to the effect of producing a definite member of a definite species.

The convergence of my own approach with that of Gurwitsch is already suggested strongly.

In physical economy (ignoring superimposed monetary processes), the characteristic event is the increase of the society's potential population-density, which has increased by about three orders of magnitude since the upper limit of a 10-million human population estimated for a pure hunting-and-gathering society. The source of this increase in population potential, is the generation of those modifications of social and individual behavior we associate today with scientific and technological progress.



The MIT Museum

Norbert Wiener in 1955, studying the record of his brain waves emerging from a new device developed at Massachusetts General Hospital, which compares brain waves in one time period with those which preceded them. Wiener's cybernetics denies the existence of human creative discovery.

Although the development of the individual scientific discoverer is socially determined, each discovery is the product of the individual human mind, although the realization of that discovery is, again, socially determined. It is in the power of the individual to generate discoveries, or related acts, which transform the potential population-density of society, in which the efficient connection between the individual (microcosm) and the society (macrocosm) is directly exhibited in physical-economic processes.

The causal connection between such advances in technology, generated by individual discoveries, and a resulting increase of the productive powers of labor (potential population-density), served thus as the most convenient point of reference for a necessary and sufficient refutation of Wiener's Cybernetics.

My concern was the feasibility of measuring this causal connection, such that technological progress, measured from the standpoint of Gaussian notions of least action, enjoy a measurable connection to ensuing increases of the productive powers of labor. On condition that Gauss-Riemann physics is comprehended in terms of the indicated synthetic geometrical elaboration of conic least action, the methods appropriate to solution of problems of measuring such "non-linear" process-connection were implicitly available.

By virtue of the derivation and elaboration of this hypothesis, what is shown to be characteristic of physical-economic processes in the most elementary terms, is also a reflection of that which is truly elementary in living processes. On this basis, during 1973, I outlined to my associates a project for estimating the impact of continued, then-prevailing trends for the collapse of human population-potential upon the proliferation of new and old varieties of epidemics and pandemics. During 1974, it became very clear that continuation of mutually re-enforcing monetary-policy and Malthusian trends would bring man-kind to the threshold of proliferating entirely new kinds of pandemics, as well as reviving old ones.

The projection made by my associates at the close of 1974, aptly forecasts the epidemiological developments of the 1980s, approximately on schedule. Although the original generation of human AIDS is unresolved, the conditions have developed which would tend to suffice to have generated such a new pandemic in nature. Whether or not AIDS is the product of accidental recombinations occurring in cancer research on human tissue, during the 1960s or later, the conditions for its proliferation were fostered by a lowering of the standard of life.

Excepting pockets of anomalous behavior (homosexuals and drug-users), the evidence is that the rate of proliferation of the infection among normal portions of the population varied according to the misery index among compared populations. Homosexuals and drug-users have had the special significance of rapidly building up a reservoir of carriers among industrially developed regions of society.

This point of view requires us to examine the way in which a rapid lowering of the potential population-density of populations, to levels below existing population-density, may cause human bodies to generate new forms of diseases, especially viral diseases. This requires mastery of the mitotic processes, treating the existence of parent and daughter cells as special aspects subsumed by a determining, morphogenetic function of mitosis. For known reasons, this requires a concentration on the spectroscopy of such mitotic functions.

The relation between the processes of the brain's cortex and the possibility of human synthetic judgment as an activity coherent with such cortical processes, becomes a central concern. The spectroscopy of these functions, from the vantage-point of mitosis in general, defines the general approach under which investigation must be broadly subsumed.

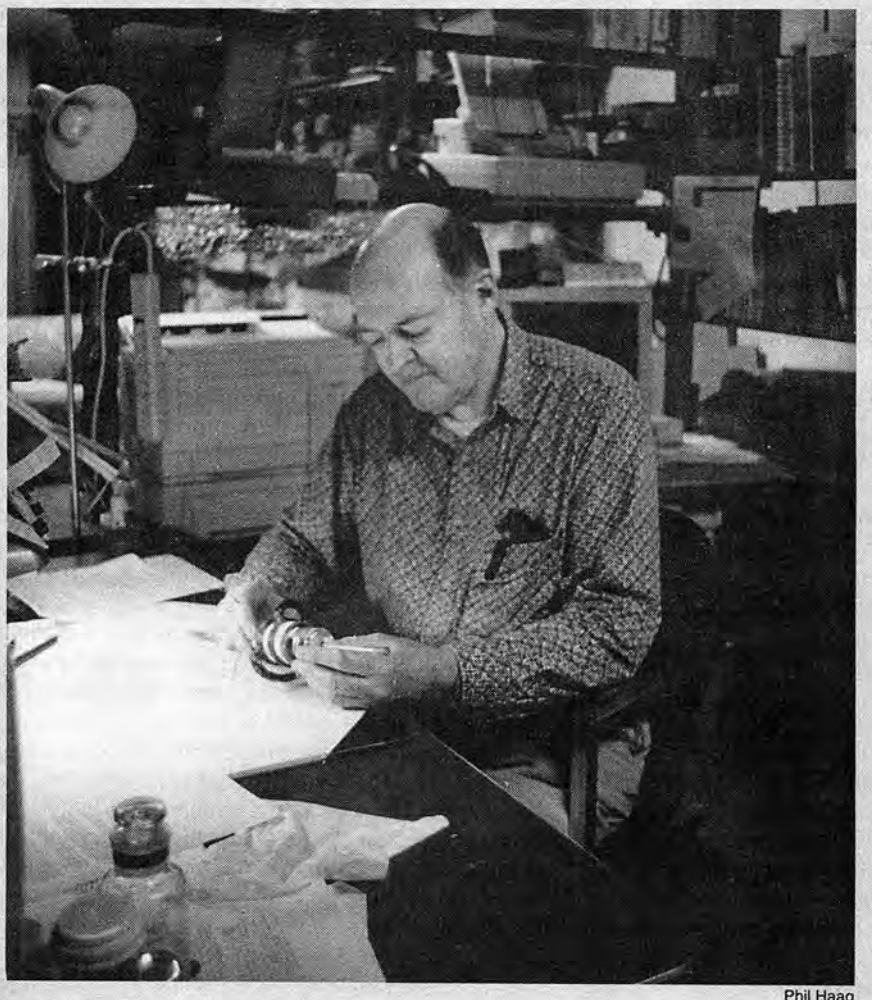
Therefore, the work of Gurwitsch is properly of extraordinary interest.

To be continued

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

Simulation of Ampèrian Current Elements by Magnetic Toroids

by Thomas E. Phipps, Jr., and Jorge Guala Valverde



Phil Haag

Author Tom Phipps in his laboratory.

A relatively simple experiment, using U-shaped magnets in a toroidal configuration, demonstrates the existence of Ampère's angular force, which has been written out of physics by Maxwell, Grassmann, Lorentz, and their epigones in today's physics establishment.

Introduction: Ampère Longitudinal Forces

In 1822, Ampère did some memorable (but largely forgotten) work identifying the law of force-action between two "current elements."[1] He devised a number of elegant null experiments, added the requirement of obedience to Newton's third law (equality, oppositeness, and collinearity of action-reaction along the line connecting interacting particles), and from these inputs derived a force law that Maxwell later termed the "cardinal law of electrodynamics."[2] In the 175 years since that time, no empirical counter-evidence to Ampère's law has been offered, with one exception that we shall mention. In the special case that the current elements lie in the same plane, this law takes the form

$$d^2\mathbf{F}_A = \frac{I_1 I_2 ds_1 ds_2}{r^2}\,\hat{\mathbf{r}}[3\cos\alpha\cdot\cos\beta - 2\cos(\alpha-\beta)] \quad \text{Eq. (1)}$$

for the idealized case in which infinitesimal filamentary current element $I_1 ds_1$ exerts an increment of force $d^2\mathbf{F}_A$ on current element $I_2 d\mathbf{s}_2$ ($ds_1 = |d\mathbf{s}_1|$, $ds_2 = |d\mathbf{s}_2|$) where $\hat{\mathbf{r}} = \mathbf{r}/r$ is the unit vector between current elements, $\mathbf{r} = \mathbf{r}_2 - \mathbf{r}_1$, $r = |\mathbf{r}|$. We have recently done independent experiments concerned with verifying this law for the interaction of "polarization currents," which may be pictured as flowing on the surface of a toroidal permanent magnet, and we report the results here.

In the geometry on which we shall focus attention, element 2 is the test element supported on an analytic balance pan, with which forces are measured, and element 1 is the force exerter fixed directly above it in the laboratory; hence, $\hat{\mathbf{r}}$ points downward, so that repulsive force is counted as positive, corresponding to a positive increment of weight registered by the balance. Here α, β are the angles with the vertical direction (counted as positive upward) made by the force-exerting element and the test element, respectively. The restriction, above, to coplanar elements is not a serious one, as Ampère showed that non-coplanar current components exert no force.

We see that Ampère treats infinitesimal directed segments as lacking physical extension, in the same way Newtonians treat idealized point "particles." Grassmann, a few years later, claimed that directed segments need not obey such rules. He ridiculed the complexity of Equation (1) and the apparent oddity that force vanishes at the strange angle $\alpha = \beta = \cos^{-1}\sqrt{2}/3 = 35.264°$. He proposed instead (still for the coplanar current element case), on the basis of aesthetics rather than physical evidence, a law of the form

$$d^2\mathbf{F}_L = \frac{I_1 I_2 ds_1 ds_2}{r^2}\,[\hat{\mathbf{r}}\cos(\alpha-\beta) + d\hat{\mathbf{s}}_1\cos\beta], \quad \text{Eq. (2)}$$

which has some advantage of simplicity, but violates Newton's third law by being asymmetrical in subscripts 1 and 2, and failing to be directed along $\hat{\mathbf{r}}$. Here, $d\hat{\mathbf{s}}_1$ is the unit vector $d\mathbf{s}_1/ds_1$. Grassmann had a mathematical axe to grind, in that he needed a selling point for a new variety of algebra that he had discovered, a forerunner of Gibbs's vector analysis. In this, he appears as a prototype of the string theorists of our own day, who seek to impose on physicists their ideas of mathematical beauty, while scrupulously shunning the laboratory. Subsequent history was kind to Grassmann, in that his law, Equation (2), was later appropriated by Lorentz and then by Einstein-Minkowski for relativity theory, by virtue of its being capable of "Lorentz covariant" expression. This was not true of Equation (1), which holds only in an instant action-at-a-distance context, such as that of the early electrodynamics of Gauss and Weber.[3]

Equation (2) is thus the famous Lorentz force law, written in an unfamiliar form. As it happens, the two laws, (1) and (2), as well as an infinitude of others, differ only by additive quantities that are *exact differentials,* which consequently integrate to zero around closed circuits.[2,4] Since current flows generally in closed circuits, this means that there is no obvious experimental way of determining Nature's preference among these candidate laws. Maxwell stated both laws and left the issue of choice entirely open.[2] Thus began an apparently interminable, and still active, "controversy." The 20th century's resolution of the scientific issue has been not scientific, but political: Textbook writers and other authorities, untrammeled by empiricism, unanimously decided that it was all right to violate Newton's third law, but not all right to violate covariance. It is possible, in lack of concrete evidence, that the experts were guided to this choice by divine revelation.

Three Ways of Resolving the Force Law Puzzle

Is there a more scientific way of addressing the issue? We shall mention three empirical approaches to resolution of the controversy of Equation (1) vs. Equation (2) that have been devised in recent years, as an introduction to a fourth way, which is our main topic. First, despite Maxwell's endorsement, [2] the idea that current must flow a*lways and only in closed circuits* is not physically valid. Current flows in stub antennas, and engineers (if not physicists) know that these are not closed circuits. (It has been claimed that transmitting and receiving antennas together form "closed circuits." But closed circuits with *separately observable parts,* as to their momentum properties, are just as embarrassing to conventional theory as non-closed circuits.) Pappas and Vaughn[5] have done momentum observations of antennas that contradict Equation (2) and confirm Newton's third law, thereby supporting Equation (1). Naturally, such work has been ignored by the experts.

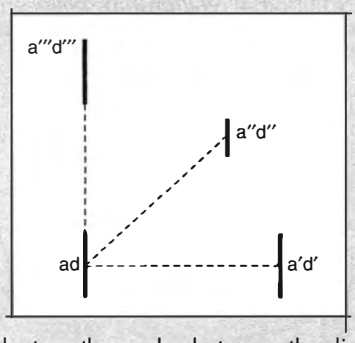
Another approach suggested by the above is to recognize that, although the laws (1) and (2) predict the same net action-reaction forces when integrated around complete circuits, they predict not at all the same magnitudes or spatial distributions of *stresses internal to the circuits.* For instance, Ampère's law predicts longitudinal repulsive forces between aligned current elements (putting $\alpha = \beta = 0°$ in (1) reduces the square bracket to 1, which is positive, indicating repulsion); hence the existence in a current-carrying wire of an "Ampère tension." Lorentz's law, however, predicts only forces transverse to current (for aligned current elements $\hat{\mathbf{r}}$ and $-d\hat{\mathbf{s}}_1$ are parallel; hence $\alpha = \beta = 0^o$ reduces the force in (2) to zero). Therefore Eq. (1) asserts, contrary to Eq. (2), that at large enough currents, the I^2 forces within a single circuit (straight wire) will become huge, and at some point must blow the wire apart. This "exploding wire" phenomenon exists and was first observed by Nasilowski,[6] who at the time (like most textbook-taught physicists), did not know of Ampère's law. It has been extensively validated by Peter Graneau[7] and others. Again, Newton and Ampère are supported and longitudinal electrodynamic forces are confirmed.

The Ampére Angular Force

In 1820, immediately following on Oersted's discovery of the effect of an electric current on a magnetic compass, Ampère adduced the basic relationships of force between current-carrying wires: Two parallel wires attract when the current flows in the same direction, and repel when the current flows in opposite directions.

But to formulate a general law, Ampère needed to determine the relationship between two infinitesimal elements of current within any two wires, in any spatial orientation to each other. For example, what would be the force between current elements ad *and* a′ d′, *as element* a′ d′ moves from position 1 to position a″ d″.

Through an intensive series of experiments, Ampère was able to determine that the force between current elements was proportional to the inverse square of the distance between them, but, unlike the other familiar forces, it was



also dependent on the angles between the directed current elements. This Ampère angular force also led to the ironic situation that two elements of current moving in the same wire, one in front of the other, would repel—the longitudinal force.

A third approach is to recognize that despite compartmentalization of the teaching of dynamics and electrodynamics, the two disciplines do interact with each other in a unified real world. The force law we assert between circuits or their elements, for instance, is tacitly predicated on the immobility of the force-exerting object: The latter is presumed rigidly connected to some large mass, so that it cannot *recoil*. If, instead, some portion of a force-exerting circuit does recoil, this "steals" energy from the interaction and selectively reduces the observable effects of the force exerted *by that portion*. The effective (observable) force is thereby weakened below what the force formula predicts. So, the inertial properties of a current-carrying circuit, determined by its mass distribution, physical configuration, stiffness, degree of mobility, or connectedness with external masses, and so on, can alter its effectiveness as an exerter of force on a test object.

If one exploits the "inertial modulation" effect just described, whereby the force exerted by portions of a circuit can be selectively modified through deliberate design choice of circuit inertial properties, one can resolve the force-law issue with electrically closed circuits—despite all the time-honored "theorems" going back to Maxwell that deny such a possibility. The reason theorists have unanimously reached a contrary conclusion, is that they have hermetically sealed their minds against the possibility of effective forces being altered by *recoil effects* resulting from imperfect inertial "anchoring" of conductors. Without stopping to think, they have treated all circuits as if infinitely massive. But infinite mass is never a realistic case. It is particularly ironical that unrealism of this sort has been allowed to dictate the dogma of unresolvability of the force law puzzle.

To date, not one authority has stepped forward to acknowledge the purely mathematical point made here, that, in principle, the statements of all accepted theorems bearing on ponderomotive interactions among circuits need, and lack, an explicit caveat to the effect that infinitely massive (or otherwise immobilized) force-exerter circuits are *assumed*. Observe that if one authority makes an oversight they all make it—and that the mistake readily propagates unto the *n*th generation of experts. Because of the importance of this third means of resolving the force law puzzle, in the following section we amplify our digression from the main topic to discuss little-known evidence for the occurrence of inertial modulation as a physical fact.

Empirical Evidence for Inertial Modulation Of Electrodynamic Force

Neal Graneau at Oxford has carried out a beautiful experiment exploiting the third approach (using the inertial modulation effect) to demonstrate the existence of Ampère longitudinal forces:[8] He used a high-voltage circuit with unequal arc gaps to get high current to pass briefly through a vertical cylindrical conducting rod, termed the "armature." If the lower arc gap was narrower than the upper, the armature was observed to jump up against gravity whenever sufficient current flowed. Longitudinal forces (parallel to current in the rod) are needed to explain this. But, in addition, recognition is needed of the special role of the inertial properties of the conductive medium within the arc gaps. For, if a gapful of current-carrying arc plasma were the same in force-exerting capability as a gapful of solid metal, carrying the same current (as the current-dependence of force formulas such as (1) and (2) might suggest), the gap widths would have made no difference, regardless of the force law, and both gaps would have been effectively of the same (zero) width.

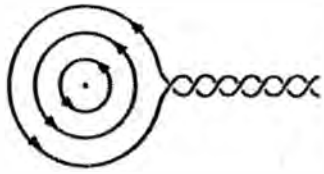
The gap symmetry at the top and bottom of the armature would have resulted in up-force and down-force cancellation, with no possibility of the observed armature jump-up. In short, the *formulas* prove that the bumblebee cannot fly—but it flies.

In actuality, the low-mass current-carrying plasma acts upon the massive armature in much the same way a colliding rowboat acts upon an ocean liner: The state of motion of the massive test body (ship) is not observably altered, and all observable recoil is allocated to the rowboat. Unlike a rigid pier attached to the shore, the rowboat can sustain little reaction,

Figure 1
THE VACE CONCEPT

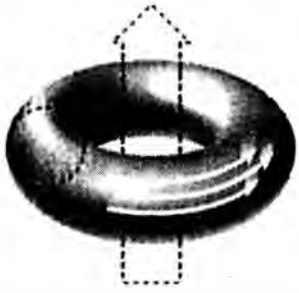
Shown is the evolution of relationships between flux and current, real and virtual (or "polarization"), leading to the VACE concept. The "stock magnet" VACE actually used in experiment is shown in (h).

(a) Wire carrying real current and surrounded by lines of force that fall off with distance from the wire

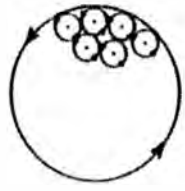


(b) Same wire as in (a), bent for form a small loop, simulating an Ampèrian current loop

(c) Ampèrian current element, represented by a short up-arrow



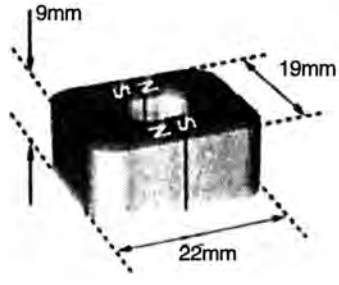
(d) Evolution of (c) in which the circulating flux lines are confined to a magnetized torus, with the current element shown dotted



(e) Enlargement of cross section of the dotted current element in (d)

(f) Current flowing on the surface of the toroid, with greater density toward the "hole"

(g) Flat, washer-shaped magnetic toroid begins to simulate the ideal Ampèrian current element of (c)



(h) Two U-shaped permanent magnets come close to producing a flux-containing torus that is a Virtual Ampèrian Current Element, or VACE.

and can thus exert correspondingly little measurable action. If the state of motion of the ship is all we can observe, the rowboat might as well not be present.

In the same way, the arc plasma is inertially "anchored" by so little self-mass, and is itself so subject to recoil, that the conductive medium in the gap is effectively not present as an exerter of observable force on the comparatively massive test body (armature rod). So it suffices as an approximation, in analyzing the Neal Graneau experiment, to consider only the solid portions ("anchored," like the pier, to the Earth) of the circuit

as force exerters, and to consider the gaps as if they exerted no force, *although all parts of the circuit carry the same current.*

The effect of inertial modulation of force in Neal Graneau's experiment, as just described, has been verified in detail by quantitative calculations already published.[9] Unfortunately, Graneau's account of *the experiment itself* has met with rejection by both American and British first-line physics journals.[8] A further irony is that the only thing in print in a scientific journal on this topic is the Robson-Sethian paper,[10] in which the experimental setup was much like that of Graneau, but in which *equal arc gaps* were used, so that force-cancellation occurred by gap symmetry. (There was circuit shape asymmetry, which Robson-Sethian assumed would suffice to reveal Ampère forces, if they existed; but it has been proven that shape does not matter and that it is *gap* asymmetry that is required for a positive demonstration of Ampère longitudinal forces.[9]) No armature jump-up could possibly have been observed in the Robson-Sethian arrangement; yet their non-observation was welcomed, and published where all physics teachers could benefit from it, as proving the nonexistence of longitudinal forces.[10] Graneau's contrary evidence showing the existence of such forces for unequal arc gaps was unanimously rejected.

Such double standards in the handling of evidence could not have existed in science before this century—nor could such universal scientific incuriosity have been credited. Here, then, is exemplary proof of what dissidents have been saying: Modern physics journals have no room to print the news that does not fit, nor do established physicists leave any room for it in their heads. Ideology (of a viciously censorious variety) has replaced empiricism in the physics of the late 20th century. Exaggerated respect for theorists (if not for theory) has led to disrespect for fact, or to the playing of favorites among facts.

The Robson-Sethian "evidence" is, as far as we know, the only empirical evidence that purports to disprove Ampère longitudinal forces and is, coincidentally, the only evidence recently accorded widespread dissemination. All other experiments we know of on the subject (there are scores—see Graneau[7]) support Ampère and, being consigned to obscurity, are consistently ignored by the vast majority of physicists. If, overlooking this majority prejudice, we here tentatively accept the extensive empirical evidence[7,8] for Ampère forces—Equation (1)—it becomes a matter of interest to relate such forces to magnetism. That is the subject of the investigations we describe below.

The VACE Concept

In 1995, one of us (JGV) and his co-workers conducted experimental studies of the interaction of permanent magnets of toroidal shape. These were the first such studies of which we are aware. In March 1996, Reginald I. Gray (now deceased) made a suggestion for a way of simulating an Ampèrian current element by means of permanent magnets in a flux-containing toroidal configuration that we shall call a Virtual Ampèrian Current Element, or VACE. This will be described below. About the same time, Gray applied for a U.S. patent on another scheme to the same end. This employed real current in a circuit, all parts of which were magnetically shielded, as by enclosing electrically insulated conductors in soft iron pipe, except for a short segment from which the current "looked out" to simulate the Ampèrian current element. Gray did experiments with contrivances of this sort, but got strange preliminary results that seem to suggest the possible dominance of unwanted apparatus effects. Gray's VACE concept seems to have proven more successful.

Let us approach this concept in successive stages, through a progression of familiar considerations. Figure 1(a) shows a long straight wire carrying real current and surrounded, as everyone since Faraday has chosen to suppose, by magnetic "lines of force" (**B**-field flux), falling off in intensity (density) with distance from the wire, and encircling it clockwise as we look down the wire in the direction of conventional current flow.

Next, in Figure 1(b), we show this same wire, now bent around to form a small loop. As the wire is bent, the density of flux lines increases on the interior side of the loop and decreases on the outside. In an imagined limit of vanishing loop size, portrayed in 1(b) by circles of decreasing size, we see that the loop contains a single line of flux, normal to the plane of the loop (out of the paper), and no flux outside; or rather, we agree to neglect the return path of the flux loop. (The current leads shown as twisted together in this diagram have no significant external magnetic effects, because equal currents flow adjacently in opposite directions, effecting clockwise and counter-clockwise flux cancellation.)

What we have in Figure 1(b), then, is a real-current simulation of an Ampèrian current loop or whorl. Similarly in thought, the latter produces a magnetic flux line normal to its plane, but is not necessarily constituted of real "circulating" current (produced by drifting electrons) but on a micro-scale might correlate with some quantum mechanical property—"probability current," electron spin, or the like. (Caution is advisable here, because coplanar electron spin effects add when oriented in the same direction, whereas coplanar Ampère whorls cancel internally. So, spins can hardly be legitimately modelled as *current circulations.*)

Figure 1(c) sketches another conceptual object, the Ampèrian "current element," represented by a very short up-arrow, encircled again by magnetic flux directed in the same way as if we were considering a short length of the wire shown in Figure 1(a). Roughly speaking, the flux is so distributed as to fall off in intensity with the inverse square of distance from the (infinitesimal) element, and is symmetrical in azimuth. But how it is distributed in polar angle (that is, with respect to the direction in which the element points) is the question on which we shall seek enlightenment. All laws—Lorentz, Ampère, and so on—agree that flux is not confined to the median plane normal to the current element, as might be suggested by Figure 1(a), because that would lead to a delta-function (discontinuous) type of interaction of two elements, which is highly implausible.

Figure 1(d) shows an evolution of Figure 1(c), in which the circulating flux lines have been gathered-in from all space and are largely confined to the interior of a permanently magnetized torus. The torus is considered to have a circular cross section, indicated by the dotted circle on the left side. The "current element" at the center is now a ghost (shown dotted) of the conceptual current element in Figure 1(c). We shall term this ghost of something imagined, a "virtual" Ampèrian current

element. For real current at this stage has faded away, like the Cheshire Cat.

Next, in Figure 1(e), we show an enlargement of the dotted cross section in Figure 1(d). This cross section of the magnet is considered to be filled with magnetic flux lines pointing out of the paper, each encircled by an Ampèrian current loop similar to that shown in 1(b). On the atomic scale, these would not be loops of real current, but would each correlate with some quantum-theoretical attribute of a magnetic domain. In the interior of the permanently magnetic material, according to the Ampère model, the effects of adjacent "currents" cancel, leaving only a counter-clockwise circulating current on the surface of the toroid. This, too, is not a "real" current in the sense of charge transport (drifting electrons). It is often referred to as a "polarization current."

Figure 1(f) shows the pseudo-current, just mentioned, flowing on the surface of the toroid. The important thing to notice here is the greater density of the encircling current lines toward the interior of the torus—that is, toward the "hole in the donut." On the outside of the torus the filaments of current are less crowded. We see that as the hole is made smaller, the current density in the center increases without limit, whereas the outer density remains finite. In the small-hole limit, the central up-current comes to resemble (in some sense of dualism) the idealized Ampèrian current element depicted in 1(c). Only a surface current is involved, but the surfaces draw together as the hole shrinks, leading to simulation of a single current filament of infinitesimal length, as in 1(c).

Hence, although real current is not involved, the relationship of surface current loops and flux lines for a flat, washer-shaped magnetic toroid, as depicted in Figure 1(g), begins increasingly well to simulate the ideal Ampèrian current element of 1(c). As the central hole in the washer is made smaller, the up-flowing surface current in the hole increases in concentration and density, thereby improving the simulation. In 1(g), as in 1(d) and 1(f), it may be assumed that magnetic flux is largely (but not necessarily entirely) confined to the toroid. Just as in 1(b) we neglected the outer return portions of the flux loops, in 1(g) we neglect the outer return portions of the surface current filament loops.

With this idealization we get a model (capable of approximate physical realization) of our famous nonesuch, the ideal Ampèrian current element. For, with a small hole in the washer, the up-flowing inner surface current is very intensely concentrated and localized, while if the washer is thin, the in-and-out surface currents on top and bottom of the washer will be close together in space, and the more or less mutual cancelling of their effects will be observable at a distance. Also, the down currents on the outside will all be comparatively short and spatially dispersed, so they can presumably be neglected.

A subtle point may be mentioned in passing: The "filamentary approximation" shown in Figure 1(f), whereby a smooth surface polarization current is bunched-up into distinct closed-loop filaments, may be invalid for calculations that depend on distinctions between Ampère and Lorentz force laws. For such laws, as we have noted, yield the same result when integrated around any closed filamentary loop. That a computational distinction between these laws might follow from an analysis based on a true two-dimensional "spread" of surface current, of varying density around the torus, is a possibility that has not, to our knowledge, been put to any test. The proposition is plausible, because variable surface current density entering into circuital integrations could spoil the purported exactness of differential integrands. There thus remains much to be learned about matters of principle on the side of theory.

Permanent magnets that largely contain their own flux, such as those we have been discussing, are not commercially available. One of us (JGV) has fabricated magnets of cylindrical toroidal shape (similar to a short section of thick-walled pipe). More will be said about the performance of these presently. Without such special efforts, the nearest one can come to producing a flux-containing torus is to cling together two horseshoe or U-shaped permanent magnets, as shown in Figure 1(h). This depicts an immediately realizable VACE or Virtual Ampèrian Current Element. It could, as in the figure, be nothing more than a pair of Alnico refrigerator magnets, oriented with their north and south poles in contact. The contained flux points conventionally from each magnet's north pole toward the adjacent south pole. The 1(h) VACE points up in the configuration shown.

What can one reasonably expect to attain by such a crude physical simulation of an idealized Ampèrian current element? The first and most important thing *not* to expect is a correct simulation of the variation of force with distance from the element. In the ideal case, this variation is as the inverse square of distance. But the radial distribution of flux confined within a magnetic toroid of finite size is all wrong to match the radial distribution in the ideal case, which goes smoothly to infinity. In fact, it was found empirically that the force action between two VACEs, such as that depicted in Figure 1(h), falls off with separation with approximately the inverse sixth-power of separation distance, instead of the desired inverse second-power.

But that is of no consequence, because we know the distance law. All theories agree on the inverse square-law dependence of force between current elements. What we do not know, and hope to learn through inference, is the force dependence on polar angles, the α and β of our candidate force laws, Equations (1) and (2). Here, hopes of empirical resolution prove to be better justified. It is found that even a very crude VACE approximation of type 1(h) to the ideal thin-washer shape 1(g) may serve to give a good indication of *angular variation* of force between two idealized Ampèrian current elements. Finally, three important points:

(1) Usually it is assumed that any toroidal shape of ideal magnetic material, magnetized for flux confinement within the material, will contain all its flux, so that there is no leakage and no external force. If that were true, two magnetic toroids, such as shown in Figure 1(g), would not interact at all, unless brought into direct contact. But, look at it the other way, in terms of surface current greatly concentrated in the central hole and dispersed elsewhere. Two such VACE's might be thought of as interacting via their intense central currents, regardless of what "flux" is pictured as doing. In other words, there could be direct physical interaction of the virtual surface currents, just as there would be between geometrically similar elements of real current. This supposition of polarization current interaction violates the presumption of field theorists that **B**-field must be present at the site of force exertion in order for magnetic force effects to be observable. But Aharonov-Bohm have already demonstrated such violation in another context.

So we ought not to close our minds, *a priori*, to the possibility, but should put it to empirical test.

(2) If the idea works at all, it should work spectacularly well, because with Alnico or better permanent magnets, the confined fluxes amount routinely to thousands of gauss, so we are talking about surface currents equivalent to thousands of amperes per transverse cm. Hence, the forces of interaction of two small VACEs separated by a few times their maximum physical dimensions, may amount to many milligrams (dynes), even hundreds of milligrams—very easily and accurately measurable by the crudest of analytic balances. So, anybody can check it out without special equipment.

(3) From the experimentalist's standpoint, the real beauty of using VACEs for force measurement is that they do not require any real current input. This means *no current leads,* which gets rid of the experimentalist's main nightmare, *viz.*, unwanted perturbations of force observations by the mechanical and other properties of current leads. Saumont has done pioneering experiments measuring Ampère longitudinal forces with an analytic balance, by getting current into a test element on the balance pan through mercury contacts.[11] One of us (TEP) has tried to replicate this, and has found it to be very tricky. One needs just the right type of optical-mechanical balance, one needs to be scrupulous about cleanliness of the mercury, etc. In fact, so far, only Saumont has demonstrated the experimental skill required to make this method work. But with VACEs, one's experimental technique can hardly be sloppy enough to prevent getting meaningful results. Needless to say, this is a great practical advantage.

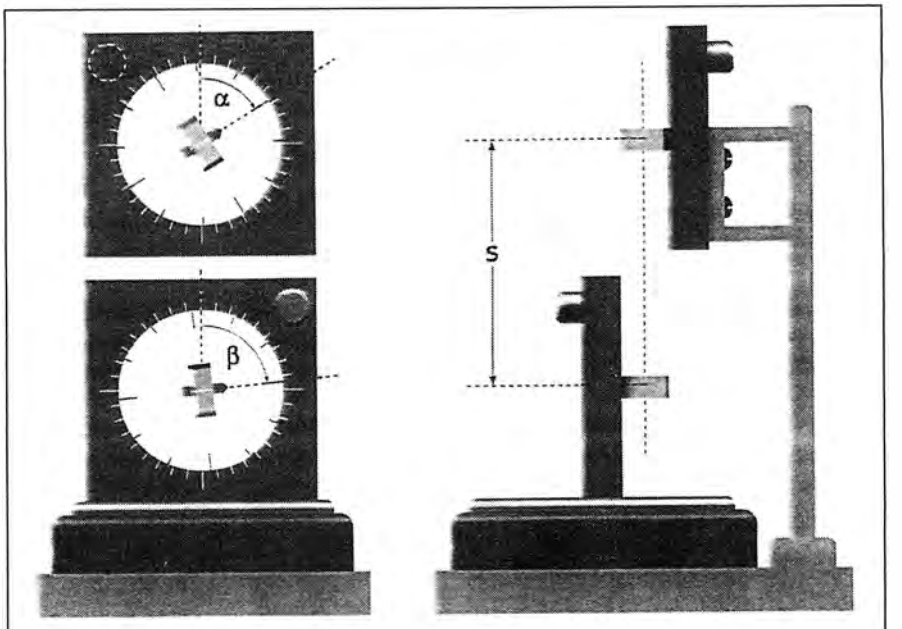


Figure 2
GEOMETRY OF VACE MEASUREMENT

The lower VACE, mounted on a rotational motion controller, is supported on the pan of an analytic balance. The upper VACE, on separate motion controller, is supported at a fixed location in the lab. The angles of coplanar VACEs can be adjusted independently without altering center separation s.

VACE Experiments with Stock Magnets

Observations were made by one of us (TEP) with two types of U-shaped magnets and one type of parenthesis-shaped (partial U) magnets. (All of these were procured as stock items from Edmund Scientific Co.) Despite the considerable variation of these shapes, all tell essentially the same story. In every case, a pair of similar coplanar VACEs interacts in polar angular (α, β) dependence (see Figure 2) in much the way predicted by the Ampère law, Equation (1). There is no resemblance to the Lorentz law, Equation (2), which is markedly different in form. The differences are so striking, that there is no point in doing hypothesis-testing or other statistical calisthenics. A glance of the eye tells the story.

Here, we shall limit attention to a typical representative VACE composed of a pair of small Alnico U-magnets of the shape and dimensions depicted in Figure 1(h). (These were bought from Edmund Scientific many years ago and are exactly duplicated by none of their current stock.) A pair of these U-magnets was epoxied onto a Plexiglas circle of diameter 4.4 cm, which was screwed to the face plate of an NRC Model RSA-1 small rotary-motion controller. This allowed the angle α or β to be varied between 0 and 360 degrees, by hand setting, maintaining the geometrical center of the VACE at a fixed position in space, while turning the Plexiglas circle "into itself," that is, rotating it in its own plane.

Two such assemblies were prepared, the lower being placed removably in a fixed, reproducible position on the balance pan of a Sartorius AC210P electronic balance, sensitive to 0.1 mg. Any other analytic balance would serve. The upper VACE was positioned reproducibly on a lab-fixed support, in such a way that its geometrical center lay directly above that of the lower VACE. The Plexiglas circles carrying the two VACEs lay in parallel (vertical) planes, in such manner that the two VACEs were coplanar, as shown in Figure 2. The separation, *s*, of the VACE centers was variable, but was kept fixed throughout any single "run" involving angle variation. We shall not concern ourselves here with the considerable amount of data that was taken on force variation with *s*, because this does not bear on the choice between laws (1) and (2). $\alpha = 0^\circ$ corresponded to the upper VACE pointing straight up; $\beta = 0^\circ$ corresponded to the lower VACE pointing similarly.

Gravitational action measured by the analytic balance acts downward. Because, in our geometry, the unit vector $\hat{\mathbf{r}}$ points downward, the observed weight changes correspond to the dot product of $\hat{\mathbf{r}}$ and the incremental force vectors given by Equations (1) and (2). For the Ampère law, this implies an angular factor, which we denote f_A,

$$f_A = 3\cos\alpha\,\cos\beta - 2\cos(\alpha - \beta). \qquad \text{Eq. (1)*}$$

For the Lorentz law, the corresponding dot product with $\hat{\mathbf{r}}$

yields (because $\hat{\mathbf{r}} \cdot \hat{\mathbf{r}} = 1$), $f_L = \cos(\alpha - \beta) + (\hat{\mathbf{r}} \cdot d\hat{\mathbf{s}}_1)\cos\beta$, or

$$f_L = \cos(\alpha - \beta) - \cos\alpha \cdot \cos\beta, \qquad \text{Eq. (2)*}$$

because , $\hat{\mathbf{r}} \cdot d\hat{\mathbf{s}}_1 = -\cos\alpha$, the minus sign resulting from the fact that $\hat{\mathbf{r}}$ points down, whereas $d\hat{\mathbf{s}}_1$ is referenced to the upward vertical direction. These angle functions are positive for force directed downward (repulsion between VACEs, registered as a positive weight increment by the balance). Three types of data runs were made with the stock magnets:

Case (A): $\beta = 0°$ (lower current element pointing straight up) was kept fixed, while α was varied in 10-degree increments from 0° to 360°. For this case we see from Equation (1)* that the Ampère law predicts an angular variation $f_A = \cos\alpha$. Equation (2)* predicts for the Lorentz law $f_L = 0$, for all α-values.

Case (B): $\beta = 90°$ (lower current element pointing horizontal) was kept fixed, while α was varied as above. For this case, the Ampère law predicts $f_A = -2\sin\alpha$, while the Lorentz law predicts $f_L = \sin\alpha$.

Case (C): The two angles are varied in 10-degree steps around the circle in synchronism, $\alpha = \beta$, so that parallelism of the VACEs is always maintained. For this case the Ampère law predicts $f_A = 3\cos^2\alpha - 2$; whereas Lorentz predicts $f_L = 1 - \cos^2\alpha$.

From this it is clear that even quite crude data should suffice to select between the two laws. We show here in Figures 3-5 the data for three runs, corresponding to the three cases just listed, for a fixed VACE center separation distance $s = 4.15$ cm in all cases. Attention is limited here to the small refrigerator magnets shown in Figure 1(h). Many other runs were made with these and other stock magnets, but these suffice to typify the results. In all cases, the measured data points are shown as cross-hatched circles, and a best-fitted (by least squares) smooth curve is shown by open stars connected by the curve.

Case (A), $\beta = 0°$, is shown in Figure 3. The empirically fitted smooth curve is given by the equation

$$f = A\cos\left[(\alpha + B)\frac{\pi}{180}\right] + C, \qquad \text{Eq. (3)}$$

where the best parameter values (obtained by Levenberg-Marquardt fitting) are $A = 15.574 \pm .08$, $B = 14.089 \pm .30$, $C = -2.70 \pm .06$, the angle B being in degrees and A, C being in milligrams. (The indicated uncertainties are one calculated standard deviation). It is apparent that the general character of the empirical curve (3) fits with the Ampère prediction $f_A = \cos\alpha$, where α is in radians rather than degrees. The main differences are a substantial phase shift of about 14 degrees, and a small additive constant force term. The latter could be a "lift" effect caused by proximity of ferrous material of any kind and shape. That is, even a handful of nails held 4 cm above a permanent magnet on the balance pan would be expected, through its attraction, to cause some reduction of the measured weight. The observed small decrease of weight almost independent of orientation of the upper VACE, measured by the parameter C in (3), can be rationalized on that basis. The goodness of fit hardly needs quantifying, but we mention that the calculated "Coefficient of Determination" (COD) is 0.9981; the Correlation Coefficient (CC) is 0.9990; and the so-called Model Selection Criterion (MSC), based on a 3-parameter fit is 6.182, a comparatively high value. The origin of the phase shift is not known. With other magnet shapes it is generally much smaller, sometimes absent.

Case (B), $\beta = 90°$, is shown in Figure 4. The fitted curve has the equation

$$f = -2\sin\left[(\alpha + B)\frac{\pi}{180}\right] \times A + C, \qquad \text{Eq. (4)}$$

where the best-fitting parameters are: $A = 22.92 \pm .11$, $B = 2.77 \pm .27$, $C = -12.044 \pm .15$. The fitting measures are COD = .9983, CC = .9992, MSC = 6.321. This time, the phase shift is much less, but the "lift" effect (C-value) is greater. There is good consistency with the Ampère result, $f_A = -2\sin\alpha$. If that consistency were perfect, the A-values in cases (A) and (B) would agree; but, in fact, they differ by about 50 percent. Still, the signs are all correct to agree with the Ampère law, and this degree of quantitative discrepancy in force magnitudes seems readily accountable by the nature of the stock magnets.

Case (C), $\alpha = \beta$, is shown in Figure 5. The empirically fitted equation is

$$f = A\left(3\cos^2\left[(\alpha + B)\frac{\pi}{180}\right] - 2\right) + C + D\sin\left(\alpha\frac{\pi}{180}\right), \qquad \text{Eq. (5)}$$

with best-fitting parameter values $A = 20.41 \pm .11$, $B = 2.415 \pm .16$, $C = -9.12 \pm .13$, $D = -11.05 \pm .17$. The fitting measures are COD = .9981, CC = .9990, MSC = 6.148. This time,

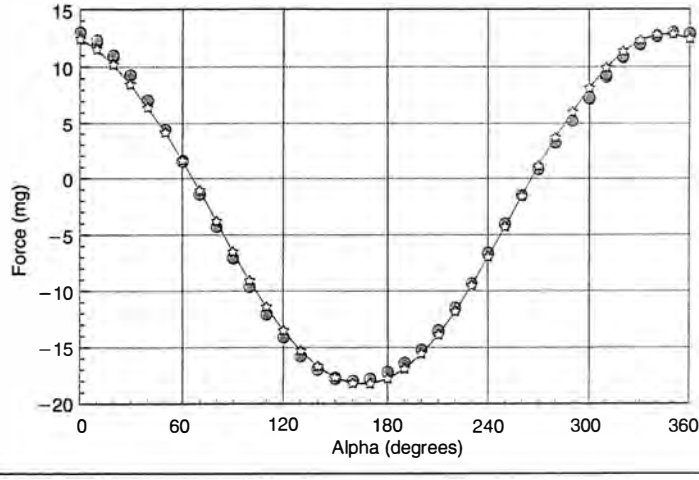


Figure 3
VARIATION OF MEASURED FORCE BETWEEN VACES WITH TEST VACE POINTING STRAIGHT UP

As described in Case (A), Equation (3). Shown is the variation of measured force between "stock magnet" VACEs with the polar angle α of (upper) force exerter, for test VACE (on balance pan) kept pointing straight up ($\beta = 0°$). Data are shaded circles; the calculated (empirically best-fitted) curve is designated by open stars connected by a line. VACE center separation is kept constant at s = 4.15 cm.

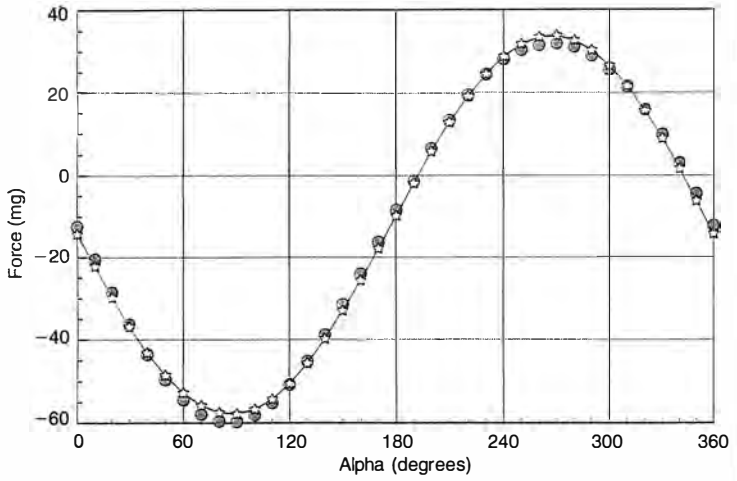


Figure 4
VARIATION OF MEASURED FORCE BETWEEN VACES WITH TEST VACE POINTING HORIZONTALLY
As described in Case (B), Equation (4). The configuration is the same as Figure 3 with the test VACE pointing horizontally (β = 90°).

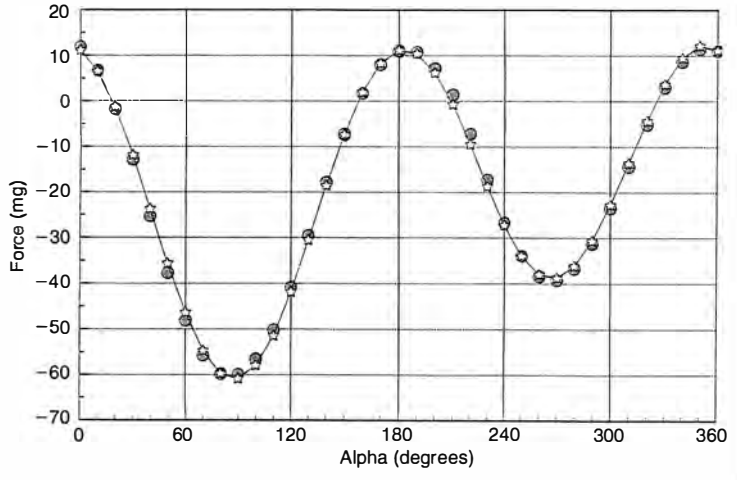


Figure 5
VARIATION OF MEASURED FORCE BETWEEN VACES WITH VACE ANGLES VARIED IN SYNCHRONISM
As described in Case (C), Equation (5). The configuration is the same, with VACE angles varied in synchronism, so that α = β. This means the two virtual Ampèrian current elements always point parallel to each other.

we have resorted to a four-parameter fit (although the phase shift *B* is small enough that getting along without it impairs the fit quality very little—for example, correlation reduced from 0.999 to 0.996). The reason is that some perturbing influence is causing the peak amplitudes to vary markedly. The likeliest explanation that comes to mind, is that the lower VACE (rotated in this case, but not in the previous ones) was mounted eccentrically. This would account qualitatively for the sine-function nature of the observed perturbation.

The explanation is plausible (a) because all mountings were done by "seaman's eye," without aids to precision; (b) because the measured variation of inter-VACE force with separation distance *s* was roughly as s^{-6}, a variation of such rapidity as to exaggerate any imprecision of mounting. Other magnets, independently mounted, did not show this apparent "eccentricity" effect. Apart from the perturbation, the agreement is good with that Ampèrian oddity, $f_A = 3\cos^2\alpha - 2$, which Grassmann rejected as incredible.

Commentary: The impression conveyed by the particular data discussed above, that the VACEs are "trying" to behave like idealized Ampèrian current elements, is confirmed by all data taken to date on three different sets of VACEs formed from stock-item magnet pairs of various sizes and shapes. All tell the same story with remarkable consistency. It seems that there is hardly anything one can do to spoil the "signature" of Ampère in the data. There are generally perturbations superposed on that basic signature, but the latter is not to be erased. In the stock magnet experiments, one message was clearly and consistently conveyed: *The virtual surface currents hypothesized by Ampère to flow on permanent magnets, when manifested in flux-containing toroidal geometries, insist on exerting forces at a distance in just the specific, complicated angular way Ampère stipulated that short "elements" of real current ought to do.* As for the Lorentz law, its supporters are going to have to look elsewhere for confirmations.

Remark on "flux leakage": On conventional ideas of magnet interaction, there is something of a mystery as to how magnets that contain their own flux are supposed to interact at all. A toroid—whether a solenoid or a permanent magnet—containing flux, is supposed to contain all its flux: Such is the accepted idealization. Similarly, an infinite straight solenoid is supposed to contain all its flux. Customary conceptions also demand the presence of **B**-field flux as a precondition for force exertion on magnetic material. So, considering their quasi-toroidal geometry, there is no conventional way to explain VACE interactions except as a consequence of flux leakage.

The substantial forces observed between VACEs arouse some doubt about this explanation. Could flux leakage be the whole story? It seemed strange that the Ampère law "signature" was so plain in all the data. Flux leakage sounds like a random and accidental sort of thing—variable with magnet shape, magnetization differences, and so on—so, why the apparent regularity of the observed consequences? What if one were to offset a pair of force-exerting magnets deliberately, so as to increase the flux leakage substantially? That was tried, and resulted in very little change in measured force between VACEs. This reinforced suspicions. A Hall-effect gaussmeter (Applied Magnetics Lab Model GM 1A) with an accurate probe was procured, and used to measure directly the leakage flux from one of the VACEs situated at the separation distance of the other. Leakage flux thus measured proved to be apparently too small by

about *a factor of five* to account for the interaction forces measured.

Something does not add up. The model of direct interaction between current elements—for instance, via an electrodynamics of the old action-at-a-distance style of Ampère and Wilhelm Weber[1, 3, 7, 11, 12] might allow measurable and observable forces to exist in the total absence of flux leakage (whatever "flux" may be, physically), provided that virtual (polarization) surface currents can be analyzed in the same way as real currents. Yet, accepted electrodynamics of the Faraday-Maxwell-Lorentz-Einstein-QED variety is helpless to understand any force action whatever between VACEs, except by loading the whole burden of explanation onto "flux leakage." This camel's back is in danger of breaking.

But that is a different story from the one we set out to tell here. Even if one hesitates to go back all the way to Gauss-Weber in order to find one's way out of the maze of theory, it seems that one must at least bring in the vector potential **A,** associated with the intense, virtual currents at the center of the VACE toroid. This seems to echo Aharonov-Bohm, as magnetic flux, or **B**-field, plays no necessary role in accounting for the phenomena dominantly observable. If this happens to be confirmed by other investigators, we hope it will raise the consciousness of the people who call themselves physicists, perhaps to a level where they can recognize the strategic advantages of nurturing over time a plurality of models of such important, and basically mysterious, phenomena as those of electromagnetism.

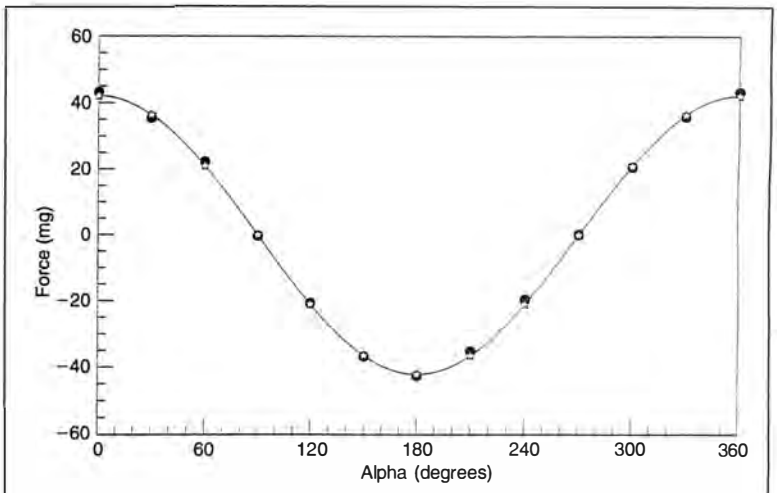


Figure 6
VARIATION OF MEASURED FORCE BETWEEN VACES, USING MORE PERFECTLY TOROIDAL VACE
As described in Case (A), Equation (3). This is the same configuration as in Figure 3, but uses a more perfectly toroidal VACE, built with prepared magnets, not stock magnets (1995 data).

VACE Experiments with Prepared Magnets

In 1995, one of us (JGV) performed interaction force measurements on pairs of specially prepared Alnico toroids. These were of more perfectly toroidal shape than any that could be formed from stock magnets. The shape can be pictured as a section of length 6 cm, cut transversely from a straight cylindrical pipe of outer diameter 6 cm and inner diameter 2 cm. These were magnetized circularly, with contained inner B-field exceeding 6,000 gauss.

The results of Case (A) measurements, similar to those described above, are graphed in Figure 6 for VACE separation s = 5.5 cm. The data points are shown as solid black circles. The best-fitting curve (marked by line-connected open stars) is of the form

$$f = A\cos\left(\alpha\frac{\pi}{180}\right); \qquad \text{Eq. (6)}$$

with parameter value $A = 42.10 \pm .33$, it yields COD = 0.99918, CC = 0.99963, MSC = 6.9624. This is in exact agreement with the Ampère law prediction, without any of the perturbations that affect the corresponding stock magnet measurements shown in Figure 3.

Thus the "Ampère signature," which was reasonably apparent in the imperfectly-toroidal stock magnet data, is entirely unmistakable in the data for the more perfect prepared toroids. Also, despite a much higher level of contained flux, the absolute level of flux leakage was no greater for the prepared magnets, because the U-magnet interfaces (conducive to leakage) were absent from the more perfect toroids. (Measured flux leakage for both types was a few gauss at 5-cm distance, and was roughly independent of VACE orientation.) Yet, the observed forces for the prepared magnets were substantially greater than those for the stock magnets. This suggests that, in general, it is not the external (leakage) B-flux that dominates VACE interactions but the *contained* B-flux, or the magnetic polarization surface current, to which the latter gives rise.

"There are things about electromagnetism that remain obscure and demand exploration unprejudiced by what is 'known' among conventional theorists. "

Maxwell's equations, which do allow for representing the source term **J** as magnetization surface current, seemingly ought to be able to cope with VACE description. But, their physical content being minimal, they are like an erector set without instructions. The vector potential can be expressed in terms of the surface current—but, when one tries to go from that to "force," what kind of force, electromotive or ponderomotive? And beware, once one has "proven" that the actions between polarization currents must be ponderomotive one has set oneself up for a new misery: Observations (which we do not discuss here) aimed at detecting ponderomotive force action between polarization current and real current, have apparently failed to show any such cross-action. How sad, that after a century's dream of self-sufficiency, theorists must still snatch peeks at empiricism.

Summary

VACEs are permanent magnetic toroids containing their own flux (to a large extent). They are not available commercially,

but can be approximated, peasant-style, by putting together a pair of U-magnets. The interactions of pairs of VACEs roughly simulate the angular dependence of the interactions of pairs of Ampèrian current elements, as evaluated by Ampère in formulating his original theory during the 1820s. The accuracy of simulation improves with increasing perfection of the toroids. The separation distance dependence of Ampèrian current elements (inverse square-law) is not correctly simulated. The successful simulation of angular dependence may prove to be a mere fluke of nature. Or, it may turn out to be a valid message signaling the existence of circumstances in which Ampère's law is superior to Lorentz's.

These are the first data we have encountered that select the Ampère law exclusively and favor it over all rivals, including alternatives,[1] due to Riemann and others, that (like Ampère) include non-vanishing longitudinal force components. The experiments are so cheap and simple that anyone can check out a favorite candidate force law by personal observation.

There is a distinct suggestion that the observed forces between VACEs are too great to be accounted for by B-flux leakage alone. Since fluxes can be measured and forces can be measured, this seems a resolvable issue. Alas, the academies can be of little help in such matters. They are prisoners of image, bound hand and foot by a self-importance that prevents their becoming implicated in projects of the high-school "science fair"-level described herein. In the bad old days, professors cravenly yielded to scientific curiosity; today, only yokels do so. Still, it would seem that there are things about electromagnetism that remain obscure and demand exploration unprejudiced by what is "known" among conventional theorists. The 21st century confronts physicists not fully ready, in terms of maturity of their science, to enter the 20th.

Thomas E. Phipps, Jr., a retired physicist, describes himself as a certified heretic in the field of modern theoretical physics. Jorge Guala Valverde works at the Instituto Julio Palacios in Neuquen, Argentina. The material in this paper is scheduled to appear in modified forms in Electric Spacecraft Journal and in Galilean Electrodynamics.

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There's No Truth to the Rising Sea-level Scare

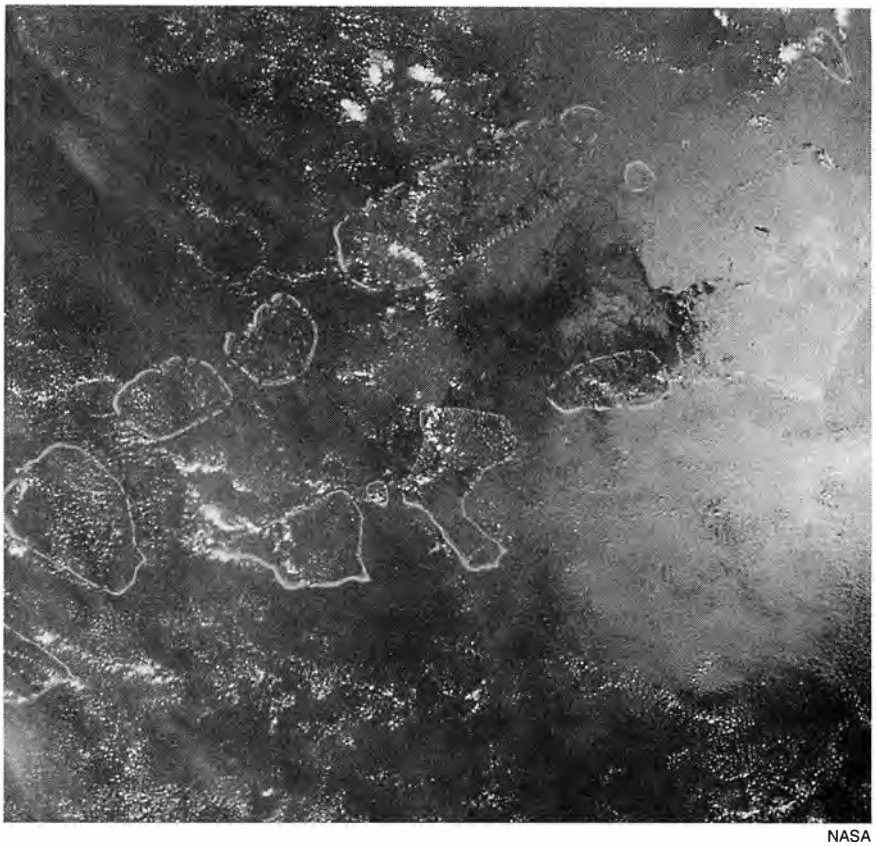
by Dr. Richard D. Terry

A marine geologist examines the myth that global warming will raise sea levels.

Global warming proponents are sounding the alarm about potential flooding of low-lying coastal areas and low islands, but the likelihood of any global warming causing a catastrophic rise of sea level is nonexistent.[1] As I shall show, there is *no* credible evidence, contemporary or historical, that a global warming will cause such flooding. Further, claims by global-warming modellers that they can predict sea level are a myth.

The processes that control or affect sea level and the origin and nature of sea level changes are complex. The ocean's surface is in constant motion and undulates. Water moves in some general direction, but the flow is turbulent and superimposed on the general movement. It is generally thought that there is a correlation between glacial lowering of sea levels and the ice tied up on the Earth's surface. Variations of atmospheric CO_2 levels and ocean temperatures are related to changes in ice volumes, and probably contribute to glacial-interglacial cycles. But, as I show, warming at the poles, means more ice, not a rise in sea level. (And note that, contrary to the propaganda, we are now at the end of an interglacial.)

Tides, which are one of the indicators of ocean levels, are difficult phenomena to measure and compare. In some parts of the world there are no tides or tidal currents; in other places, tides exceed 50 ft.[2] Tide-gauges record sea levels throughout the world, although records are limited prior to 1900. These tide-gauges are not well distributed around the world, and the records are usually irregular, requiring statistical analyses to compare any two stations. The biggest problem is that most tide-gauges are on unstable foundations; no known place on Earth is free from Earth movement. Therefore, no completely satisfactory data exist to measure or compare relative sea levels.[3]



NASA

The Maldive Islands, a chain of atolls south of India, and chief example of threatened inundation used by the global warming propagandists. Taken from the Space Shuttle in April 1984, the photo shows the coral atolls and cones visible in the lagoons.

Solid-Earth processes that affect sea level come in many varieties: Earth movements, geological faulting, vertical movements caused by earthquakes, sea-floor uplift and subsidence, sea-floor topography, volcanism and thermal effects (super plumes, sea-floor emanations, Earth degassing), changes of land and ocean areas, sedimentation and compaction, isostasy,[4] geoidal effects, Earth pulsations and cycles, and astronomical forces. As can be seen in the table, page 70, movements of the Earth's surface can be exceedingly large.

Other processes are oceanic and climatic: glacial surges and ice melting; climate effects (drastic weather changes that occur randomly); ocean effects (steric ocean response, temperature and salinity), long-period tides, shelf-waves and seiches, gravity waves, and others. Most of these processes are poorly understood and difficult to model, because they are not linear.

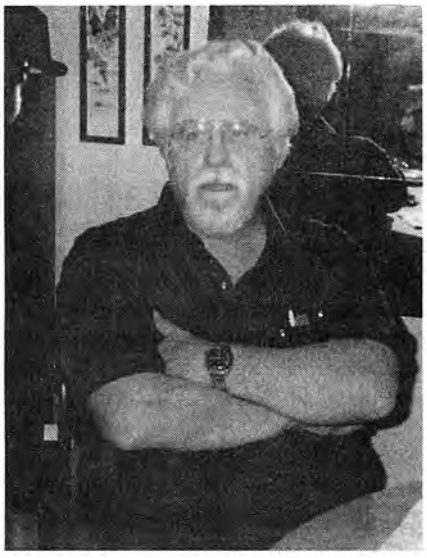
Dubious Assumptions

Global warming "predictions" are actually based on dubious assumptions, unsupported by measurement or testing. For example, global-warming advocates *assume* that they can accurately model climate and forecast sea level. But, can they?

Shortly before his death, physicist Horace Lamb wrote, "I am an old man now, and when I die and go to heaven there are two matters on which I hope for enlightenment. One is quantum electrodynamics and the other is turbulence in fluids." Werner Heisenberg, a German physicist who helped define quantum mechanics, made a similar comment on his death bed: "There are two questions for God; why relativity, and why turbulence." Heisenberg added: "I think He may have an answer to the first question."

Climate modellers *assume* that the atmosphere behaves in a linear, non-turbulent, fashion. They must do so, because otherwise they cannot possibly model in detail the atmosphere or the oceans, both of which are chaotic and nonlinear. Nonlinear forces operate throughout the universe and have long haunted physicists, oceanographers, and astronomers. Lamb and Heisenberg were simply emphasizing the fact that turbulence is, so far, beyond their comprehension.[5]

A sampling of climate modelling will help the reader understand both the process and its shortcomings.[6] In a computer simulation, the atmosphere is broken down into a series of boxes in a grid. Each box covers an area of several hundred square miles, and boxes are stacked on top of one another. Inside each box, the laws of physics and chemistry are applied to what is happening at any given time. All the climatically significant variables are averaged across the grid boxes, or are assumed to have a linear change from one side of the box to the other. Modellers take into account that air and water vapor can move between boxes, and predictions (or best guesses) are made of events as they unfold. Ultimately, a "picture" will be displayed on a computer screen or a series of graphs that can be manipulated.



Author Richard Terry: "There is no credible evidence, contemporary or historical, that a global warming will cause flooding of low-lying areas."

The major problem in simulations is that they hardly ever mimic the "real world," which is bewilderingly complex and still has many unknowns. For example, models have difficulties with: the effects of rainfall on vegetation and soils, the growth and shrinkage of sea ice, combining climate and ocean circulation, and variations of energy from the Sun, especially cloud cover. One climate model, shows Death Valley filled with water! In another, oceans are modelled as a "swamp."

A look at some case examples from contemporary modelling indicates their limitations and questionable conclusions.

- In 1994, Christe and McNider[7] made an attempt to rescue the global warming scenario by examining the lower tropopause (lower 3 miles) of the Earth's atmosphere, using satellite microwave measurements for the past 15 years. They plotted sea-surface temperatures, El Niño events, volcanic eruptions (El Chichón and Mount Pinatubo), and they arrived at an upward temperature trend of only +0.09°C per decade. This "best estimate" is five-fold less than that predicted by the publicized global-warming models.
- In 1993, using the computer models on which global warming is based, 30 authors attempted to calculate atmospheric temperature for 100 years into the future, by means of the standard deviations of the 15 different models. They started this work partly because not one model had correctly predicted atmospheric temperature during the preceding 10 years![8]
- "Doomsayer" Stephen H. Schneider, noting the claimed atmospheric temperature increase of +0.5°C during the 20th century, pointed out in *Science* in 1994, that such an increase had happened only twice in a thousand years. He then offered the extraordinary conclusion that there is a 80 to 90 percent *probability* that the 20th century increase can be attributed to man-made carbon dioxide.[9] As I show, this is a completely arbitrary and provably false assumption.

What about Temperature?

How have temperatures varied during the last few hundreds and thousands of years, and is a small rise of temperature a cause for concern?

Fossilized records of the population of midge larvae are one of the best indicators of temperature, because they pinpoint temperatures to within 1°C. Steve Brooks, an entomologist studying midges in bogs in Scotland and western Norway, found dramatic fluctuations 5,000 years after the end of the Ice Ages, ~14,000 YBP (years before the present). The largest fluctuations were in the Younger Dryas, when the ice caps retreated in North America and Europe. In Scotland, at the start of the Younger Dryas, summer temperatures crashed by about 10°C over just a few decades. This glacial reprise lasted for about 1,500 years.

Two other sudden and shorter freezes occurred around 12,500 YBP, when summer temperatures plummeted, in Scotland, 1.5°C for about 150 years.[10] Similar data are reported from Canada, inferring, again, large swings in temperature. Unexplained rapid temperature oscillations, as much as 5° to 10°C, on the Greenland Ice Sheet are the norm.[11] Moreover, it has been confidently stated that the world is heading for another ice age. A case in point is the Northwest Territories of Canada, where temperatures

have declined 5°C since the Climatic Maximum, 6,000 years ago.[12]

These reports make temperature modelling suspect. One must wonder why a temperature increase of ≈1°C or so, warrants immediate attention when recent geologic history records much larger fluctuations over short time-scales.

Nevertheless, it is *assumed* that computer models are sufficiently accurate to model an increase in atmospheric temperature over many decades. It is also

The IPCC's Rising Catastrophe Level

To give legitimacy to the "man-induced global-warming" hoax, in 1988 the Director of the United Nations Environment Program announced the formation of the Intergovernmental Panel on Climate Change (IPCC), which was to operate under the auspices of the World Meteorological Organization. In his opening address to the Panel, Chairman Dr. Bert Bolin concluded: "I think that human-induced climate change is on its way. This is my view, and it is shared by a majority of the scientists engaged in research in this field."

Bolin's statement was a clear enunciation of the conclusion that would eventually be presented to the world. It was the first, but by no means the last, deliberate prevarication to be pronounced from the "Global-Warming Mount."

In June 1990, the first Working Group Reports of the IPCC were made public. From the Executive Summary WG 1, "Scientific Assessment of Climate Change," we learned that (1) "the global mean temperature has increased by 0.3°-0.6°C" in the past century, and (2) "global sea level has increased by 10-20 cm." Furthermore, we were told that ". . . this warming is of the same magnitude as natural climate variability," and "Unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more."

Oceanographic observations through 1990 had established that sea level had been rising at a rate of about 11 centimeters/100 years for at least the last 300 years. The sea-level numbers and the warming numbers stated in the report were certainly not of any great note.

Ah, but then came the predictions: Should the major countries not reduce, significantly, the use of fossil fuels, and thereby CO_2 emissions, the report said, then the rate of increase of global mean air temperatures during the next century would be "about 0.3°C/decade." Worldwide temperatures would be "1°C higher than the present value by the year 2025, and 3°C before the end of the next century."

In the same time period, the report stated, the sea level would rise at "an average rate of 6 cm/decade (with an uncertainty range of 3 to 10 cm/decade), mainly due to [sic] thermal expansion of the oceans and the melting of some land ice." Thus, by the end of the year 2,100, sea level would be "65 cm higher than today."

That was a staggering prediction, not because of its magnitude, but rather because of its completely erroneous claim that a 1°C increase in air temperature would produce nearly a 2-foot rise in sea level by thermal expansion! Clearly, those preparing the report had no comprehension of the ocean's thermodynamics. Had they made the simplest calculations, they would have learned that a 1°C rise in air temperature would be absorbed in the top 1 meter of the ocean, producing a negligible increase in water temperature and an imperceptible thermal expansion.

To raise sea level by 2 feet would require an 8°C increase in air temperature over a period of 13,200 years!

This prediction of rising sea level was quickly countered by geophysical oceanographers, who were quite comfortable with the recognized rate of sea-level rise of 11 cm/century, and who thought that the truth would soon be known.

It was not! Instead, not only did the IPCC continue to promote the impossible, totally unscientific, "thermodynamics," but political leaders of the Western world, and the well-funded non-governmental organizations, began to circulate the "catastrophe story" throughout the 14 independent island nations that their protective coral reefs would soon be submerged! If these nations did not band together, and attempt to force restrictions on the industrial countries' use of fossil fuels, they were told, their island nations would disappear beneath the ocean waves. Band together they did, under the guidance and counsel of Greenpeace, the most militant of the "Green" NGOs.

All of this mental, political, social, and cultural agony could have been avoided easily, had the IPCC included fundamental oceanographic knowledge in their deliberations, and done so with forthright honesty. In fact, the normal rate of growth of tropical reef-building corals has been measured by oceanographers at 12 mm/year—that is, 1.2 cm, or exactly 1/2 inch. Furthermore, during the most rapid rise of sea level after the last glacial period, between 8,000 and 10,000 years ago, the upward growth of coral reefs was more than 1 inch per year.

Consequently, whatever the rate of rise of sea level fabricated by IPCC, the World Meteorological Organization, and the INEP, and trumpeted by political leaders, no tropical coral reefs would be submerged!

The deliberate, dishonorable lies about sea-level rise to the citizens of the widely spread out, and mainly tropical islands, caused great anxiety, and great expenditure of funds by governments that could not afford such spending. Efforts by the oceanographic community to provide real data and real information to the leaders of the island nations, were stopped by UNEP, IPCC, and cooperative executive agencies of the Western nations.

In this article by Dr. Richard D. Terry, a respected and well-known marine geologist for half a century, the geophysical details of sea level are presented with care and scientific integrity. The article aims to relieve the minds of millions of island citizens, that their nations aren't going under, and to remind the global warming bandwagon scientists of the real science involved.

—Robert E. Stevenson, Ph.D.

Global warming and the stability of the West Antarctic Ice Sheet

Michael Oppenheimer

Of today's great ice sheets, the West Antarctic Ice Sheet poses the most immediate threat of a large sea-level rise, owing to its potential instability. Complete release of its ice to the ocean would raise global mean sea level by four to six metres, causing major coastal flooding worldwide. Human-induced climate change may play a significant role in controlling the long-term stability of the West Antarctic Ice Sheet and in determining its contribution to sea-level change in the n

This is the opening of an article by Environmental Defense Fund scientist Michael Oppenheimer in the May 28 issue of Nature *magazine, which was then spread throughout the national media.*

assumed that the major source of CO_2 is industrial and man-made. But industrial sources contribute only 6 billion tons of CO_2 annually, compared to 700 billion tons from natural geologic and biologic process.[13] Major natural perturbations—volcanism, sea floor hydrothermal emanations, changes in ocean CO_2 levels, sea floor $CaCO_2$, atmospheric CO_2—are parts of Earth's natural dynamic system that have taken place throughout geologic time. The present CO_2 level is ~360 ppm (parts per million).[14] Historically, atmospheric CO_2 levels have fluctuated over wide ranges throughout geologic time, as have temperatures.

A proto-ocean, the outgrowth of impacts of accretion, produced a growing Earth that had an H_2O-CO_2 atmosphere.[15] Partial pressures of CO_2 atmospheres in the Archean (earlier than 550 million YBP) are estimated to have been 100 to 1,000 times greater than the present day.[16] Atmospheric CO_2 levels during the Cambrian (560 to 500 mYBP) were between 3.7 to 14.7 times that of the supposed modern pre-industrial value of 285 ppm.[17] Superplume tectonics during the Cretaceous (~140 to 70 mYBP) produced large CO_2 emissions. During the Early and Late Miocene (20 to 8 mYBP), pCO_2 was less than 700 ppm, but was as high as ~3,000 ppm in the Early Cretaceous and Early Jurassic (~200 mYBP).

Over the last 100 million years, the partial pressure of CO_2 was near a factor of 2.5 greater than the present atmospheric CO_2 level during the post-Eocene time (<36 mYBP), and slightly below a factor of 10 for the Late Cretaceous (90 to 100 mYBP).[18] The Last Glacial Maximum atmosphere is thought to have had a CO_2 level between 50(±30) and 95(±50) ppm higher. The glacial atmosphere would have had, therefore, a CO_2 partial pressure of between 330 and 375 ppm. In the Holocene interglacial (<0.5 mYBP), CO_2 was as high as during the last interglacial.[20]

These levels of CO_2 are consistent with another study,[21] which plotted atmospheric CO_2 against geologic time (in millions of YBP) as a simple ratio of CO_2 levels compared to the present day. The conclusions are: Even in the earliest geologic times, CO_2 levels were exceedingly high. At the end of the Cambrian period (~500 mYBP), atmospheric CO_2 levels dropped, and during the Carboniferous (~300 mYBP), CO_2 levels were lower than the present day. Concentrations of CO_2 increased again ~100 mYBP when, in the Cretaceous-Tertiary (<65 mYBP), CO_2 levels were ~300 ppm.

To summarize, CO_2 levels were higher than the present for nearly 2.5 billion YBP. *Low CO_2 levels are a modern phenomenon—"modern," meaning the past 60 million years!*

Why? That is the question. But it's not global warming!

Sea-level Predictions Elude Modellers

Now, on to predicting sea level.

Global warming modellers *assume* that they can predict sea level—and that they can do so with breathtaking precision. Of course, this implies that modellers are able to take into account *all* the aspects of the Earth and ocean processes noted above. Earth scientists agree that predicting ocean volume changes and sea levels are difficult and, as will be discussed later, sea levels are barely measurable, and the predicted changes are well within sea-level "noise" range. In the final analysis, when it comes to the Earth sciences, including oceanography and geophysics, global warming modellers are out of their milieu.

Nonetheless, global-warming proponents *assume* that the United Nations climate models are accurate, thus permitting them to make accurate sea-level predictions. The difficulty in assessing sea-level modelling values is that the modellers present us with a moving target; that is, their sea level predictions keep changing.

One study states that there will be a rise in sea level of 10 feet by the year 2024. Elsewhere, we are told that a 4°C rise in temperature would cause sea level to rise 2 m in 500 years. In 1980, global-warming prognosticators estimated a 25-ft rise of sea level over the next 150 years.[22] The 1985 Intergovernmental Panel on Climate Change (IPCC) report projected a "best estimate" rise of sea level of 3 ft.[23] In the same year, a report by the U.S. National Research Council, chaired by M.F. Meier, also reduced the projected sea level rise to 3 ft.[24] Then, 1989, Meier, allowing for more water vapor and other factors, calculated that sea level in 2050 would rise about 1 ft.[25]

As for the IPCC, in 1989, its estimate of rise of sea level dropped to 1 foot. Then, in 1990, the IPCC report projected a "best estimate" of 66 cm for sea level rise in the next century.[26]

By 1992, however, other scientists were predicting that sea levels would *fall* by −1 ft., also as a result of global warming.[27] A Canadian-American team of scientists reported that ice sheets will grow in size as a result of more water being tied up as snow, causing sea level to drop in the next century.[28] At the same time, others predicted that on the basis of a forecast of a 6° to 8°F rise in temperature, sea level would rise 1 to 3ft, as a result of the thermal expansion of the oceans.

When Real Numbers Are Used

Emery and Aubrey summarized the actual sea-level measurements from 1914 to 1990. The estimates range from a low of <500 mm/1,000 years to a high of 3,000 mm/1,000 years. Most values appear to be about 1,500 mm/1,000 years.[29] Over the past 600 million years, sea level has risen at an average rate of only 1,000 mm/1,000 years.

Emery and Aubrey's statistical summaries were prepared for global sea levels. For the entire world, using tide-gauges for more than 10 years, the mean annual sea-level, relative to 1950, shows a downward (falling sea level) trend-line, with a slope of −14. Next, they used only tide-gauge stations on what they considered to be stable coasts. These data depicted an upward-sloping trend (rising sea level), with a slope of +0.8. Then, using all tide-gauge stations for the world, from 1807, the trend-line gave a downward slope of −0.9.

Tide-gauge records from 1986 onward, show a rising sea level trend with a slope of +0.6. Other tide-gauge summaries gave a wide range of trend-lines, such as, a rising sea level for the U.S. Atlantic coast (slope = +2.1 since 1898, and a rising trend-line of +3.1 since 1923. Emery and Aubrey also summarized tide-gauge results for Fennoscandia, where the land is undergoing isostatic rebound from deglaciation. As expected, there is a steep decline of relative sea levels (−3.3), because the land is rising.

From these studies, several important conclusions can be reached:

- Great caution (if not skepticism) should be given to any predicted sea level.
- Tide-gauges records are extremely variable, owing to Earth movements.
- Emery and Aubrey were unable to cite a single value to describe global eustatic sea level; all tide-gauge records show either a rising or falling sea level.
- Claims by global-warming modellers that they can predict sea level are not real. In a word, predicting sea level is well nigh impossible.
- There is *no* credible evidence that global warming will cause flooding of low-lying areas. Ten years ago, when global warming alarms first sounded, had policy-makers built sea walls at great expense to protect coastal areas, it would have been a totally wasted effort.[30]

TYPICAL VERTICAL EARTH MOVEMENTS (In mm/1,000 years)[1]

Location	Uplift/Subsidence
Arctic Coast of N. America	+200-20,000
Southern California	5,000-10,000
Japan, Boos Peninsula	−22,000 to +6,000
Japan, South Kanto District	−10,000 to +10,000
Kuril-Kamchatka trench and Islands	10,000-14,000
Loyalty Ridge, Southwest Pacific	40,000
Taiwan	19,000 to 20,000
Solomon Islands	20 to 10,000
North coast of Aitape	11,360
Surtsey, Iceland	40,800
Campi Flegrel, Italy	200,000[2]
Limnos, Greece	−10,000

Notes
1. Numbers without plus sign (+) are uplift rates; minus sign (−) denotes subsidence.
2. Highest known uplift rate.

Now to Fairy Tale

A recent global-warming sea-level study along the California coast used a global warming forecast of a 60-cm rise by the year 2040 as a baseline.[31] The authors then offered the specter of various threats to the coastal zone—shoreline recession, coastal erosion, extreme natural ocean processes (such as extreme tides and storm surges), El Niño episodes, and so on.

Now, a global-warming-induced 60-cm rise in sea level in 43 years amounts to a rise of 14,000 mm/1,000 years, which is far greater than the most reliable sea level estimates using tide gauges and historic sea level information. Further, a sea-level rise of 60 cm in a half-century would be impossible to detect, because the sea surface is in constant motion, with perturbations that reach 60 cm or more. A 60-cm rise is orders of magnitude less than the ocean's volume (329,000 km^3); such a rise is a minuscule portion of the ocean. Further, a 60-cm rise in sea level is well within the "noise"-range of sea-level measurements.

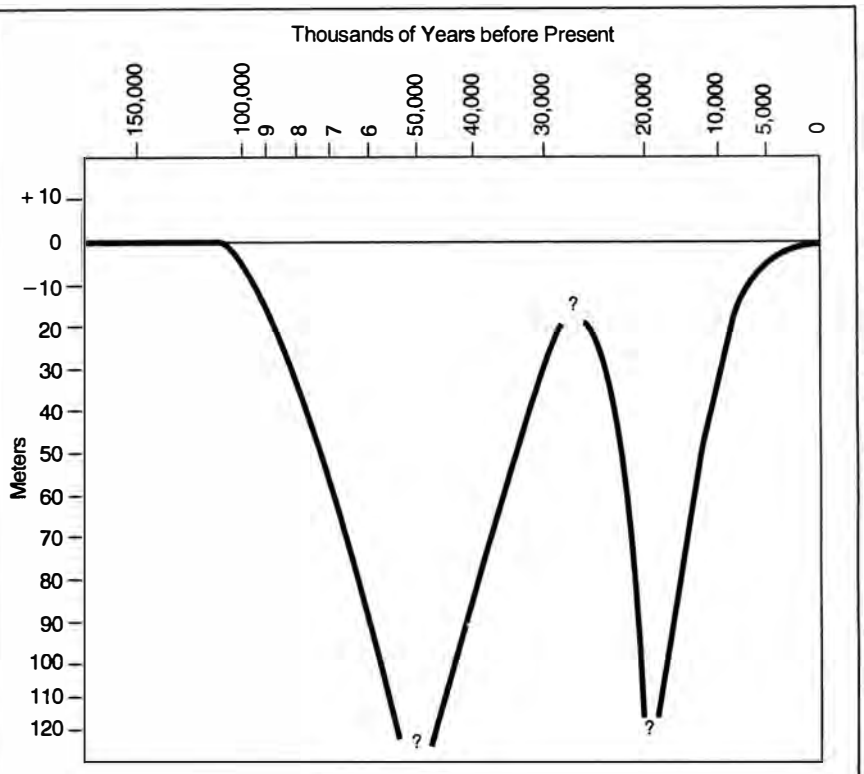
As Barrett[32] notes, there is a low-frequency (1 cycle/100 years); consequently, a ". . . change in [relative sea level] as a result of man-induced effects will be difficult, if not impossible, to detect on any realistic time scale."

Where Does the Water Come from?

Now, we must understand that 97 percent of the water on Earth is in the ocean. If one wishes to raise the ocean's level (sea level, that is), a tremendous amount of water must be found and put into the ocean. It is generally *assumed* that the largest potential source of water to raise sea level is glacial ice. Most climate models today, however, foresee increased precipitation. If that were to happen, as we shall see, there is a good chance that sea level will *drop* as much as 2 ft in the next century.

Why? Because increased evaporation locks up more water and puts more ice on the Antarctic ice sheet.[33]

The Arctic Ocean has a deep ocean basin that is covered entirely by floating sea ice (frozen sea water). The density of sea ice is 0.92 gm/cm^3. The temperature at which sea ice freezes is −1.9°C; salt lowers the freezing point of water. The colder the solid form gets, the less dense it becomes. Sea ice floats because it is less dense than when it is liquid form and, once frozen, ice occupies 10 percent more space. This means that



SEA LEVELS OVER THE PAST 150,000 YEARS

This approximate curve of sea levels is based on various measuring methods. Similar curves have been made from carbon-14 dates and the depths at which coastal fossils were found on the continental shelves.

Source: Adapted from F.P. Shepard and J.R. Curray, 1967. "Carbon-14 Determination of Sea Level Changes in Stable Areas." In *Progress in Oceanography, Vol. 4* (Oxford: Pergamon), p. 283.

melting of sea ice does *not* cause sea level to rise; it actually lowers (local) sea level.

It has been claimed that ice in the Arctic is melting; however, after analyzing 27,000 temperature readings, Professor Jonathan Kahl found a statistically significant trend in the opposite direction—today the Arctic is cooling.[34] Both the Greenland and Antarctica ice caps have been growing in recent years.

More than 90 percent of all ice is stored on the Antarctic continent; Greenland accounts for only 5 percent, and glaciers the remainder. The quantity of water stored in glaciers is debatable, but certainly is insignificant in any asserted impact on the oceans.

Global warming will have *no* effect on the Antarctica ice cap. There are several reasons. Melting of ice on any continental ice sheet takes place only at the bottom, where it is warmed by geothermal heat. The top of an ice sheet is cold (−50°C) and dry. Even with substantial heating, ice would not melt, because of its large thermal response time. The ice cap is thick, and ice itself acts as an excellent insulator, protecting it from melting.

Even if the air temperature rose, say 6° to 7°C, the ice cap would still have a temperature of ~−46°C, and the Ice Sheet would remain solid.[35] The air temperature above the ice sheet must reach 1°C before ice would begin to melt, and it would take †5,000 years to melt the ice cap—*if* global warming could cause the temperature to rise this much.

It is generally accepted that the rise of sea level in postglacial time required melting of ice at a rate of 5,000 km^3 for 7,000 yrs.[36]

As the air temperature heats up, it holds more water vapor. This is the opposite of the theory of global warming's basic assumptions. If the mean air temperature around Antarctica were to rise, more clouds would develop; more clouds would cause the air temperature to fall. Water evaporated from the oceans would accumulate as snow and become "locked up" on the ice sheet. Therefore, the ice sheet would thicken.[37] This process would lower sea level by about 1 foot.

From all this, we can confidently say that global warming's basic argument—*warming will cause sea level to rise*—is completely at odds with the dynamics of the hydrologic cycle. This self-regulating process, which restores equilibrium, is a well-known principle that every freshman college chemistry student learns.[38]

It often has been stated that, if melting of the Antarctic ice cap took place, sea level would rise ~150 ft, a figure widely reported by the media. This is a lie, as already mentioned. The Antarctic Ice Sheet will *grow,* rather than diminish, if temperatures increase in the next century, accumulating snow faster than it loses ice. Antarctica has little meltwater, owing to the extreme cold, but a small amount reportedly reaches the ocean from the East Antarctic Ice Sheet.

If the Antarctic Ice Sheet were to completely melt, the air temperature of Antarctica would have to be 1°C or higher, over thousands of years. Not only that, but in order to get the temperature of Antarctica to rise to 1°C, the entire atmosphere would have to have a temperature increase of ~51°C—210° F. (Imagine Washington, D.C., summer temperatures of 210°F. . . .)

For these reasons, the Antarctic ice sheet can obviously be ignored in global warming scenarios. No one expects the melting of the Antarctic Ice Sheet, even with a 7-fold increase in CO_2.[39]

This leaves the global warming flood propagandists with only Greenland, mountain glaciers, and ice bergs, all of which are trivial sources of water. As one writer summed up the problem of modelling sea level rises from glacier melting, "Wide uncertainties still remain."[40] And, as glaciologist F.B. Wood has pointed out, "If there were a magic way to melt all the land glaciers of the Northern Hemisphere, sea level would rise only 10 cm."[41]

Ah, but if we can't raise sea level by melting the ice, global-warming advocates then pull out of their hat the fallacy of *thermal expansion* of the ocean. In theory, this could raise sea level 1 to 2 ft, but, as we have seen, such a small rise would not be apparent. And then, too, it

would take about 13,000 years for the action to take place.

Why Global Warming?

Given the absurdity of the claims of global warming propagandists about ice melt, why do they persist in scaring people about rising ocean levels? My conclusion is that it's purely political, and has to do with population reduction.

Global-warming gurus have built careers and fortunes warning people that sea level is rising. These fear-mongers feed on the public's lack of knowledge about the true facts. They counsel people living in low-lying coastal areas—usually with the help of a pliant and ignorant media—that they are in danger of being inundated by a rising sea. These gurus have argued that a rising sea level is already demonstrated by the wide oscillations of lake levels in the Caspian Sea. (A Russian geologist, however, has shown that the fluctuations are caused by tension and compression in the Earth's crust.[42])

People living in the coastal zone are being frightened into thinking that they are about to lose everything. They are told that they can expect higher-than-normal tides and storm surges, El Niño events, hurricanes, tidal waves, and the like. The media—TV, newspapers, even pseudoscientific publications[43]—use archival films and photographs showing calamitous ocean and climatic events, passing them off as if they happened a few days ago.

Australian scientist Peter Sawyer characterized the situation this way: "It's a bit hard to reduce people to a state of fear and panic with the 'threat' of more food and better climatic conditions [from warmer temperatures], so something else had to be found. It's a measure of just how flimsy the whole greenhouse argument is, that the worst 'threat' that could be presented was that oceans-levels will somehow rise, and flood out some coastal areas."[44]

It's time for people to wake up, realize the serious consequences stemming from the policies of global warming hacks and bureaucrats, and fight back with the truth. The real global warming catastrophe is how easy it is for some scientists to scare people with scenarios that have no scientific validity.

The author of five books and many technical articles, Richard Terry is a World War II veteran of the U.S. Navy, who received his advanced degrees in marine geology from the University of Southern California. For many years he worked in the marine division of North American Rockwell. Dr. Terry has served as consultant to the U.S. Defense Department, the Assistant Secretary of the Navy (R&D), the Strategic Defense Initiative, and several space programs. He has also worked as a consulting geologist in East Africa and the Middle East. Now retired, he continues to work on advanced concepts in marine geology.

Notes

1. See, for example, "An Oceanographer Looks at Global Warming," by Dr. Robert Stevenson, *21st Century*, Winter 1996-1997, p. 51, and "What Man-made Global Warming?" by Dr. Hugh Ellsaesser, *21st Century*, Summer 1997, p. 61.
2. All units are in their original. The reason is that, when converting to metric units, errors are introduced and give the reader a false sense of accuracy.
3. This problem is analyzed by K.O. Emery and D.C. Aubrey, 1991. *Sea Levels, Land Levels, and Tide Gauges.* (New York: Springer-Verlag).
4. Isostacy is "the mechanism whereby areas of the crust rise or subside until the mass of their topography is buoyantly supported or compensated by the thickness of the crust below, which floats on the denser mantle. The theory is that continents and mountains are supported by low-density crustal 'roots.'" From *Earth*, 2nd Ed., by Frank Press and Raymond Siever (San Francisco: W.H. Freeman and Company, 1978).
5. In recent years, the word chaos has replaced the term turbulence, but it is allied with turbulence in fluids. Climatologists have used the term *fluid dynamics*, because the atmosphere behaves like a turbulent fluid. As one writer stated, ". . . the proper algorithms [for turbulence] models . . . so far has eluded physicists and the heftiest supercomputers on the planet." (*New Scientist*, July 5, 1997, p. 52). Richard Feynman struggled for years on the problem of turbulence of gases and fluids, as described by J. Gleick in *Genius* (Vintage Books, 1992).
6. Emery and Aubrey, *op. cit.* (pp. 163-165) and "Computing Difficulties in Generating Accurate Forecasts," In *Scientific Perspectives on the Greenhouse Problem*, 1989. George C. Marshall Inst., pp. 10-14. This give excellent descriptions of the current status of modelling of the atmosphere and oceans.
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Revisiting the Simplest Discoveries

by Jonathan Tennenbaum

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Solar observatory in Samarkand, Uzbekistan, built around 1420 by the Tartar prince Ulugh Beg, who also had many large astronomical instruments, and carried out careful observations of the stars.

Are ideas and concepts somehow preprogrammed into our brains, by some sort of genetic code? Or do they come from the outside, through sense perceptions, or some other way? Or do our minds have the power to generate new ideas, for example, in the form of discoveries of new scientific principles—ideas which existed neither in our minds, nor in the outside world prior to their discovery? Few questions have such far-reaching implications as these.

In a posthumously published fragment titled, "Attempt at a Theory of the Fundamental Concepts of Mathematics and Physics As the Basis for the Explication of Nature," and in other writings, the great 19th century mathematician and physicist Bernhard Riemann developed an historical approach to the origin of ideas and concepts, which is well worth studying today. Riemann wrote:

"On the basis of the concepts, through which we grasp the natural world, we not only constantly supplement our observations, but, in addition, we determine certain future observations in advance as necessary, or—in case our system of concepts is not sufficiently complete—as probable; on this basis it is determined, what is 'possible' (that is, also what is 'necessary' or that whose opposite is impossible); furthermore, the degree of possibility (the 'probability') of every single event so judged possible, can be mathematically determined, when the concepts are sufficiently precise.

"If an event occurs, which is necessary or probable according to the given system of concepts, then that system is thereby confirmed; and it is on the basis of this confirmation through experience, that we base our confidence in those concepts.

"But if something unexpected occurs, being impossible or improbable according to the given system of concepts, then the task arises, to enlarge the system, or, where necessary, to transform it, in such a way that the observed event ceases to be impossible or improbable according to the enlarged or improved system of concepts. The extension or improvement of the conceptual system constitutes the 'explanation' of the unexpected event. Through this process, our understanding of Nature gradually becomes more comprehensive and more true, while at the same time reaching ever deeper beneath the surface of the phenomena.

"The history of the exact sciences, as far as we can follow it backwards in time, demonstrates that this, in fact, is the pathway by which our knowledge of Nature has progressed. The systems of concepts, which form the basis of our present understanding of Nature, were generated by progressive transformations of older conceptual systems; and the reasons that pushed forward the generation of new modes of explanation, can in every case be traced back to contradictions or improbabilities arising in older modes of explanation.

"Thus, the generation of new concepts, insofar as it is accessible to observation, occurs by this process.

"Herbart, on the other hand, has provided proof, that those concepts, upon which our conceptualization of the world is based, but whose origins we can neither trace back in history, nor in our own development, because they are transmitted together with language without being noticed—all of those concepts, insofar as they are more than mere forms of connection between simple sense perceptions, can be derived from the above source; and need not be attributed to some special property of the human soul, assumed to predate all experience (as Kant claimed to do with his categories)."

An Obvious Case

Often it is most instructive, in exploring the implications of a fundamental principle such as Riemann's, to focus attention on the most deceptively simple cases—cases of the sort fools would be likely to dismiss as being "too obvious to be worth thinking about."

Take, for example, the everyday concept of a "day." What could be more self-evident? Does Riemann actually mean to say that there is a real, creative *discovery* embedded in that idea? What would have been the paradox or paradoxes, whose resolution gave birth to the concept of "a day"? Evidently, the discovery involved predates history in the usual sense. We might try to project ourselves mentally back to a hypothetical, very, very distant point in time, at which the concept of "a day" did not exist, and then ask: What paradoxes *must intrinsically* confront a mind in the process of freeing itself from a naive, beast-like belief in the primacy of sense-perception? First, reflect on the following:

Could we discover anything without memory? Is a pot-head Yahoo, who cannot remember what he saw or did five minutes earlier, able to make scientific discoveries? Would a Yahoo ever have been able even to discover the existence of a "day" as a recurring cycle of light and darkness? Or was the development of poetry, as a means of development of the powers of memory, crucial to the emergence of human civilization?

Pre-Socratic Greek tradition often spoke of the origin of the Universe in terms of the creation of Order (Cosmos) out of Chaos. Does this not exactly describe the subjective process by which a human mind frees itself from the blind impulses of "animal instinct" and "sense certainty"? The world of the existentialist Yahoo, or a newly born infant, is a kind of Chaos, a "kaleidoscope of feelings" replacing each other in more or less rapid succession. Mankind could not survive, were it not possible to awaken a power of *creative discovery* in the infant, or the supposedly infant-like, primitive man—a mental function energized by the most powerful human emotion, *Agape*. It is that agapic power, inseparable from the faculty of *memory* as understood by the Renaissance, which conquers the Chaos of bestiality and creates the Cosmos of human development as an ordering of successive acts of discovery.

Next, consider the elementary paradox of change, as it is addressed by the simplest of astronomical discoveries. The following exploration is hypothetical, but necessarily touches upon a discovery actually made (and in fact, made repeatedly in various forms) in human history.

You are a prehistoric human being, living perhaps 500,000 years ago. On a beautiful clear night, you seek a place to lie down under the open sky. Gaze up, from there, at the magnificent canopy of the heavens! The myriad stars shine down on you in majestic silence, like little lights affixed to a lofty dome. Here is peace, here is rest! You close your eyes and relax.

You wake up later that night. As your eyes once more open to the sky, you are struck with a sudden sense of strangeness. Something is different! Something has happened! The stars seem to have changed. Looking around, you recognize a group of bright stars, whose form you remember having remarked before you took your nap. That group of stars is no longer where it was before; the stars have changed position!

Changed? How is that possible? You stare intently at the stars. Not the slightest motion is perceptible; only a gentle twinkling while they remain, seemingly immovable, in their places.

A paradox! On the one hand, your faculty of sense perception insists that the stars are fixed and motionless. On the other hand, you remember that the same faculty had earlier testified, no less insistently, to an arrangement of stars in the sky, which is different from the one it now reports!

Intrigued, you repeat the experiment, but with a variation: You ask a friend to keep watching the stars, without interruption, during the time your eyes are closed. The experiment is performed. Once again, you find an undeniable change in the positions of the stars, when you look at the sky again after a nap. Your friend, however, swears he never saw the stars move!

A Paradox

The paradox strikes deep into your mind. Whatever follows, will depend on how you respond to the paradox. However you respond—or even if you do *not* respond—that response will reflect some sort of *hypothesis,* an hypothesis generated nowhere but inside your own mind.

Shall you merely conclude that your eyes (or those of your friend) have lied to you in some arbitrary fashion? Or that the Universe itself is maliciously arbitrary? If so, then how would human existence be possible?

Or is there another way out? Perhaps we should not *completely* reject the evidence of our senses. Perhaps it were better to assume, that although our sense perceptions in themselves do not represent reality, still there must be some implicitly discoverable, lawful relationship between sense perception and reality. This is the pathway of science.

Choosing that pathway, the paradox moves us to hypothesize the existence of something, which our senses—in virtue of some lawful limitation of the same—cannot grasp: to hypothesize a concept of a *process of change,* which in itself is *invisible* to the senses, but yet efficiently accounts for the observed (or rather, remembered) *difference* in positions! That adduced concept, of an invisible—but efficient—process of change, is an object of a different sort than a sense perception (including the paradoxical entity we commonly identify as the "perception of motion"). It is not sufficient to account for that new concept, by merely saying: "the stars move too slowly for our eyes to see." The point is, that the paradox just presented, evokes the potential of a *new quality of relationship of our mind to the Universe.*

A change in the substance of our mind! Prior to the explosion of the paradox, you looked at the Universe (the starried heavens) as an object of sense perception. Now, you are looking at the Universe from the standpoint of a

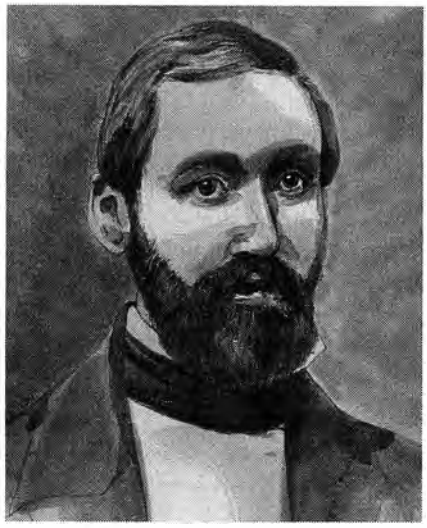
process of discovery, which stands in ironical contrast to naive belief in sense perception. To the reflecting mind, that *difference in mental attitude,* from before to now, provokes the hypothesis of *higher species of change*—a process of improvement of human cognitive powers, which is invisible to our senses, but real and earthshakingly powerful nonetheless.

Turning once more to our nightly observations, what shall be our next step? Does our power of discovery give us the capability to hypothesize, not only the existence, but also the *form* of the process of change of position of the stars? How would we discover the coherence between the paradox of the stars' motion, and a similar paradox, posed by the behavior of the Sun? And how could we do that, using nothing more than the means which were available to prehistoric Man?

Lest the reader find the above discussion "too trivial" to be important, consider the following. Nearly everyone today is faced (or will be soon) with a congruent form of paradox: On the one hand, most people would claim that their most deeply held values and beliefs, being absolutely self-evident (to them!) are fixed and unchangeable. On the other hand, comparing those "deeply held personal values" of today, with the corresponding values held "self-evidently" by those same people 30 years ago, we find almost nothing in common! If mankind is to survive, an increasing ration of leading and ordinary citizens must be brought to discover, as an "enemy image," the process by which the oligarchy was able to induce that radical, downward paradigm shift in their own minds.

The 'One' and the 'Many'

Have you ever stopped to consider, how a human being, a "mere infinitesimal" on the scale of the world as a whole, could actually come to know the vast dimensions of the solar system, or to measure astronomical cycles hundreds or thousands of times longer than the brief span of his or her individual life? The existence of such powers of cognition, by which the "infinitesimal" can know the macrocosm within its own internal mental processes, is the central issue in the bitter, millennial conflict between the human species and the oligarchical "Gods of Olympus."



Bernhard Riemann: "But if something unexpected occurs, being impossible or improbable according to the given system of concepts, then the task arises, to enlarge the system, or, where necessary, to transform it, in such a way that the observed event ceases to be impossible or improbable according to the enlarged or improved system of concepts."

Witness the words of Aeschylus' Prometheus:

"Believe not, that I from pride or stubbornness
Keep silent. Heart-rending thoughts I nurture,
Watching myself thus trodden under foot.
And yet to the new Gods, they—Was it not I
Who granted them their fitting honors?
But, of this I'll say nothing. Besides, it were to those who know
That I would address you. But, of the dire need of Men
Let me tell, how I made them, foolish at first,
To be full of thought and empowered with Reason.
I say this not to complain of them,
But only to explain the goodly intention of my gifts.
They, who had eyes from the first, but saw not,
Who had ears, yet heard not; but like figments
Of dreams, their entire life long
Mixed all things blindly together, and knew nothing
Of bricklaid houses and walls,
But lived deep-down in sunless caves
Like hordes of ants,
And knew nothing: no sign to foretell the winter storm,
Nor the spring rich in flowers, nor the fruitful
Summer, no sure measure. Without Reason did they act
In everything, 'til I made them heed the rising and setting
Of the stars, so difficult to distinguish.
And number, a most ingenious invention,
I created for them, and the invention of writing
As a monument to all, and Mother of the Muses.
And 'twas I that first put the wild beasts under yoke,
That they do service to the plough and bear burdens, and so
Lift many a heavy task from the backs of men.
And to the wagons I hitched, eager willing to obey,
Horses, the splendor of wealth.
And to sail o'er the seas—none but I
Invented the shipman's winged sails.
Yet I, who for mortals such things
Created, can find nothing for myself
To deliver me from my present plight."

Not without cause did Aeschylus emphasize the earliest discoveries of astronomy, connected with the construction of a solar calendar, as crucial events in the emergence of human reason as "the sure measure" of things.

Implicitly, the discoveries made by our pre-historic colleague in connection with the "invisible" motion of the stars, refute everything university students have been taught to believe about science and liberal arts since the mid-1960s. Astronomical cycles—beginning with the "day"—are neither objects of sense perception, nor "significant statistical correlations." Rather, the astronomical cycles emerge as *conceptions* created in the human mind, through a process of generation of paradoxes and their creative solution.

Change and No Change

From this standpoint, let us push our exploration of prehistorical discoveries a few steps further, to identify paradoxes which *necessarily* must have arisen, even though we do not now know the specific historical circumstances.

Our prehistoric observer notes: (1) The positions of the stars appear to undergo a constant process of change. (2) But, at the same time, certain arrays of stars,

Does our power of discovery give us the capability to hypothesize, not only the existence, but also the form of the process of change of position of the stars?

identified and fixed in memory through poetic (mnemonic) devices from earliest times, remain seemingly unchanged throughout the course of a night, reappearing every night with the same distinct form. Also, apart from the appearance and disappearance of stars on the horizon, the overall configuration of the constellations in relation to each other in the sky—"the constellation of constellations"—remains unchanged.

This paradox of "change" combined with "no change" evokes the notion, that the "invisible" motion of the stars, has an implicitly intelligible *form*. That paradoxical idea becomes a specific thought-object, undergoing its own process of evolution in the direction of a notion of a *universal, rotational action* subsuming both the process of change in the night sky, and the daily motion of the Sun.

Indeed, observation of the rising and setting of the Sun, and studying the Sun's overall motion, using such means as observation of the shadows cast by a pole (gnomon), demonstrates an overall *coherence* between the nightly motion of the "constellation of constellations" and the motion of the Sun during daytime. As singularities of the hypothesized universal action, we get (among other things) the differentiation of East, West, North, and South as determinate directions on the Earth's surface.

In this way, we revolutionize the naive empirical notion of a "day" as a mere "yin-yang" alternation of light and darkness. Instead, we conceive the day as an astronomical cycle, subsuming an *increasing density of distinct events* within a single ordered totality. Just as the gnomon's shadow progressively transits the markings of a primitive sundial, including the meridian, defined by the position of longest shadow; so the cycle of the "day" (that is, day and night as an integrated process) subsumes and orders the events of rising and setting of stars and constellations, and their transit across angular positions defined by the sightings of a primitive stellar observatory. From the development of these methods, our predecessors established the regular division of the day, and an indispensible means for harmonically ordering the activities of society.

But, there is a far-reaching paradox embedded in this splendid hypothesis of the day's rotational cycle as a universal ordering principle! Looming long on the horizon of our prehistoric astronomer's mind, but now growing in urgency, is the realization, that the day itself is subject to *change*. For example, the array of constellations, which are visible in the sky just before sunrise, is strikingly different in winter than in summer. To investigate the origin of this difference, identify a star or constellation, whose setting in the West immediately precedes the rising of the Sun in the East. Within a few days, we become aware of a slight delay in the appearance of the Sun, after the selected star or constellation sets in the West. The delay keeps growing: The Sun seems to be slipping backward in time relative to the stars! That apparent slippage constitutes a new, anomalous degree of change. Again, the question is posed: what is the exact *form* of this change?

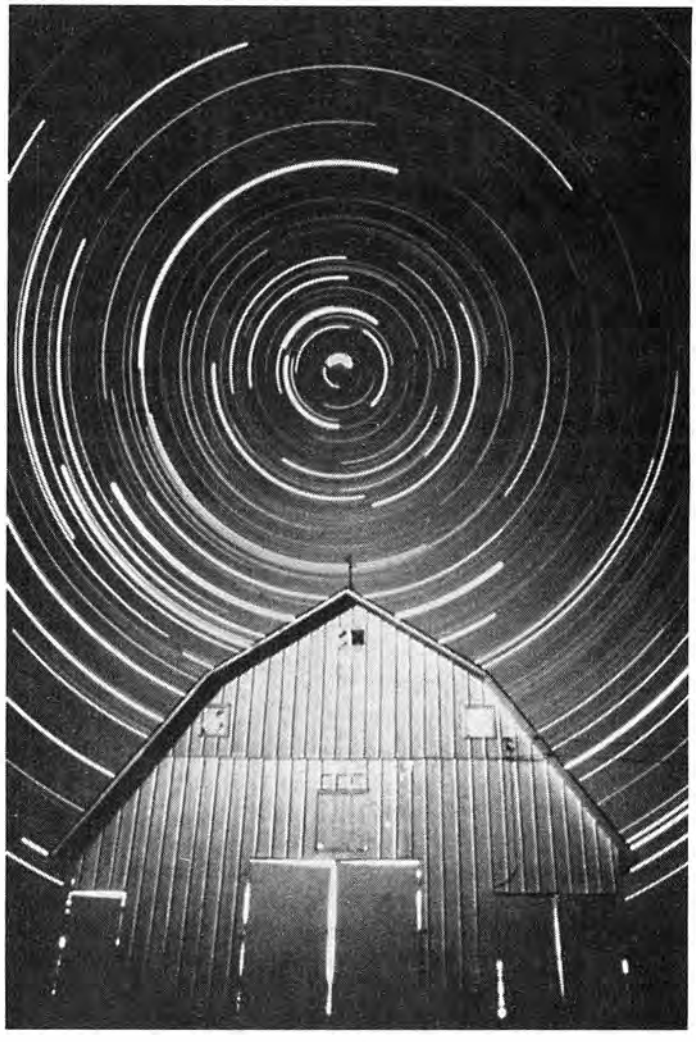
Our prehistoric astronomer juxtaposes this solar anomaly with a whole cluster of paradoxes, connected with the empirical cycle of "the year." The empirical notion of a year as a mere alternation of hot and cold seasons, or periodic recurrence of monsoons, floods or other natural phenomena, bespeaks the nearly bestial state of Man before Prometheus bestowed his gifts. The mere counting of days before the recurrence of some terrestrial event, leads to erratic results, falling far short of the "sure sign" promised by Prometheus.

Worse, was the attempt to arbitrarily impose upon society, a nonexistent correlation between changes in season and the cycles of the Moon. So, the Babylonians (and others) insisted on a calendar based on the "synodic lunar month," as defined by the recurrence of the full moon after approximately 29.5 days. After the passage of a mere 18 "years" of 12 synodic lunar months each, winter now occurs in the months where summer used to be, and vice versa! The attempt to "fix" this monstrous failure with the addition of special days and alternation of longer and shorter months, while rejecting the primacy of the solar cycles and insisting on the cult of the Moon (or some "rotten compromise" between the two), is typical of the psychosis which dooms every oligarchical empire to collapse.

Although the present Western calendar is entirely solar-based, and our months have no correlation to the phases of the Moon, the term "month" still remains as an apparent relic of Babylonian lunacy.

In contrast, by adducing a new, "solar long cycle" from the *anomaly* posed by the slight discrepancy between the solar motion and daily stellar motion, our prehistoric astronomer was eventually able to invent a "sure measure" of the seasonal cycle, which remains true over centuries and even millennia! The result is best demonstrated by the spherical sundials of the ancient Greeks, which registered not only the daily trajectory of the Sun, but also the cycle of variation of the Sun's approximately circular pathway in the sky, over a period of approximately 364 days. That cycle subsumes the cycle of change in the relative lengths of night and day, as well as the angles of inclination of the Sun's rays to the Earth's surface, providing in turn an intelligible basis for the variation of the seasons.

But, the manner in which the yearly solar cycle modulates the daily one, ordering the variations of the latter, implicitly poses a new array of paradoxes. For example: If the day is variable, might not the year be so also? And, in fact, careful observation of the loci of rising or setting of the Sun and the stars, by means of suitable horizon markers and observation points, revealed a very slight—but distinct—anomaly in the solar cycle. From this, the ancient astronomers were able, thousands of years ago, to adduce an approximately 26,000-year cycle of the precession of the equinoxes! The result is a third, "long cycle" modulating the year. The latter, according to our best present knowledge, determines the cycle of ice ages, together with a fourth anomaly, namely, the elliptical character of the Earth-Sun orbit.



Jim W. Grace/Science Source, Photo Researchers

Apart from the appearance and disappearance of stars on the horizon, the overall configuration of the constellations in relation to each other in the sky, remains unchanged. Here, a time-exposure photo, showing the North Star and six hours of star trains.

In the face of a growing multiplicity of astronomical cycles, another paradox emerges: Ancient history records repeated attempts, from the earliest recorded times, to integrate various astronomical cycles into a single calendar. This was sometimes connected with the idea, that some Great Cycle of the whole universe must exist, which subsumes all other astronomical cycles. Yet even for the case of two simple astronomical cycles—such as the day and the solar year, or the year and the lunar month—no single calendar could be constructed, that would harmonize them. According to the available historical evidence, it was the work of the Pythagorean school on incommensurable proportions, that first supplied a theoretical explanation for this curious difficulty of harmonizing two or more astronomical cycles. In light of that work, the paradox became even stronger:

If there exists no fixed arithmetical relationship which can combine the various cycles, then how can we conceptualize the "One" which subsumes the successive emergence of new astronomical cycles as apparent new degrees of freedom of action in our Universe? How do we master the paradoxical principle of Heraclitus, that "nothing is constant except change?"

Cycloids and Epicycloids

Once our prehistoric predecessors had created the concept of a day, year, and other astronomical cycles, a new fundamental paradox arose: By its very nature, a cycle is a "One" which subsumes and orders a "Many" of astronomical or other events into a single whole. But what about the multitude of astronomical cycles? Must there not also exist a higher-order "One," which subsumes the astronomical cycles into a single whole?

We can follow the traces of Man's hypothesizing on this issue, back to the most ancient of recorded times, and beyond. The oldest sections of the Vedic hymns—astronomical songs passed down by oral tradition for thousands of years before being written down—are pervaded with a sense of the implicitly paradoxical relationship among various astronomical cycles, as an underlying motif. That motif, in turn, shaped the long historical struggle to develop and perfect astronomically based calendars, as a means to organize the activities of society in accordance with Natural Law.

A familiar example of the problem involved, is the relationship of the day (as the cycle of rotation of the entire array of the "fixed stars") and the solar year. Egyptian astronomers made rather precise measurements of the solar year, including the slight, but measurable discrepancy between a solar year and 365 full days. Four solar years constitute nearly exactly 1,461 days (4 × 365, plus 1, the additional day appearing in the

present-day calendar as the extra day of a leap year). The 4-year cycle was taken as the basis of the Julian calendar, instituted by Julius Caesar in 45 B.C. (The preceding calendar had accumulated discrepancies to the point that January came in the autumn).

But the apparent coincidence of 4 years and 1,461 days is not a perfect one; a small, measurable discrepancy exists, amounting to an average of about *11 minutes per year.* This tiny "error" eventually led to the reform of the Julian calendar, in 1582, by which time the discrepancy had accumulated to about 10 days.

Another classical example is the cycle of Meton, invented in ancient Greece in the attempt to reconcile the cycle of the synodic month (defined by the phases of the Moon) with the solar year. Observation shows, that a solar year is about 10.9 days longer than 12 synodic months. Assuming the first day of a year and the first day of a synodic month coincide at some point, the same coincidence will occur once again after 19 years (235 synodic months). In fact, 19 solar years are nearly exactly equivalent in length to 235 synodic months. That defines the 19-year cycle of Meton, which was relatively successful as the basis for astronomical tables constructed in ancient Greece. But again, more careful observation shows that this apparent cycle of coincidence is not a precise one. A slight discrepancy exists, between 19 years and 235 synodic months, which would cause any attempted solar-lunar calendar based on rigid adherence to the Metonic great cycle, to diverge more and more from reality in the course of time.

The same paradox emerges, with even greater intensity, as soon as we try to include the motions of the planets in a generalized calendar of astronomical events. In fact, after centuries of effort, no one has been able to devise a method of calculating the relationship of the astronomical cycles, which will not eventually (that is, after a sufficiently long period of time) give wildly erroneous values, when compared to the actual motions of the Sun, stars, and planets! No matter how sophisticated a mathematical scheme we might set up, and no matter how well it appears to approximate the real phenomena within a certain domain, that domain of approximate validity is strictly finite. Outside that finite region, the scheme becomes useless—its validity has died.

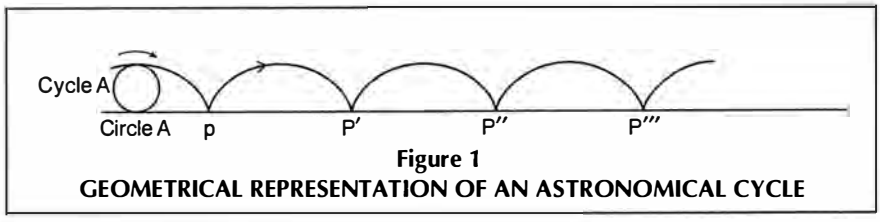


Figure 1
GEOMETRICAL REPRESENTATION OF AN ASTRONOMICAL CYCLE

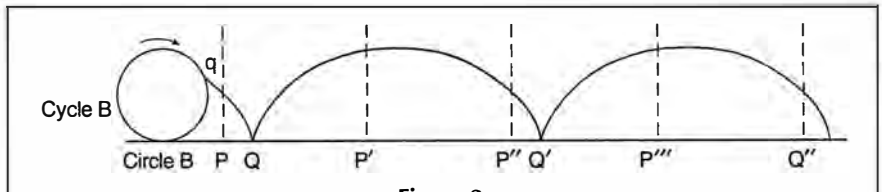


Figure 2
A SECOND CYCLE

What is the reason for this persistent phenomenon, which we might call "the mortality of calendars?" Should we shrug our shoulders and take this as a merely negative fact of life? Or is there a positive *physical existence* waiting to be discovered—a new, relatively transcendent *physical principle,* accounting for the seeming impossibility of uniting two or more astronomical cycles into a single whole by any sort of fixed mathematical construction?

A Geometrical Metaphor

According to the available evidence, the Pythagorean school in ancient Greece attacked this problem with the help of certain geometrical metaphors, perhaps along something like the following lines.

The simplest notion of an astronomical cycle embodies two elementary paradoxes: First, a cycle would appear to constitute an *unchanging process of change.* Indeed, the astronomical motions, subsumed by a given cycle, constitute *change;* whereas the cycle itself seems to persist *unchanged,* as if to constitute an existence "above time." Second, we know that the *real* Universe progresses and develops; hence, the astronomical cycles, while relatively unchangeable relative to the visible astronomical motions, are themselves subject to change.

Reacting to these paradoxes, let us construct the following simple-minded representation of astronomical cycles, in the form of a geometrical metaphor:

Represent the unity of any astronomical cycle by a circle *A,* of fixed radius. Roll the circle along a straight line, or on an extremely large circle (Figure 1). Choose a point *P,* fixed on the circumference of the rolling circle, to signify the beginning (and also the end) of each repetition of the cycle. As the circle rolls forward, the point *P* will move on a *cycloidal path,* reaching the lowest point, where it touches the line, at regular intervals. This is the location where the cycloid, traced by *P* in the course of its motion, generates a singular event known as a *cusp.* Denote the series of evenly spaced cusps, by *P, P′, P″,* and so on. The interval between each cusp and its immediate successor in the series, corresponds to a single completed cycle of rotation of the circle *A.*

(For some purposes, we might represent the length of an astronomical cycle simply by the linear segment ′, and the unfolding of subsequent cycles by a sequence of congruent segments ′, ″, ‴, and so on, situated end-to-end along a line. In so doing, however, it is important to keep in mind, that this were a mere projection of the image of the rolling circle, the latter being relatively more truthful.)

The fun starts, when we introduce a *second* astronomical cycle! Represent this cycle by a circle *B,* rolling simultaneously with the first one on the same line and at the same forward rate. Let *Q* denote a point on circle *B,* chosen to mark the beginning of each new cycle of *B.* A second array of points is generated long the line, corresponding to the beginning/ending points of the second cycle: *Q, Q′, Q″,* and so on (Figure 2).

Now, examine the relationship between these two arrays of singularities *P,′, P″,* . . . and *Q, Q′, Q″,* . . . . Depending on the relationship between the

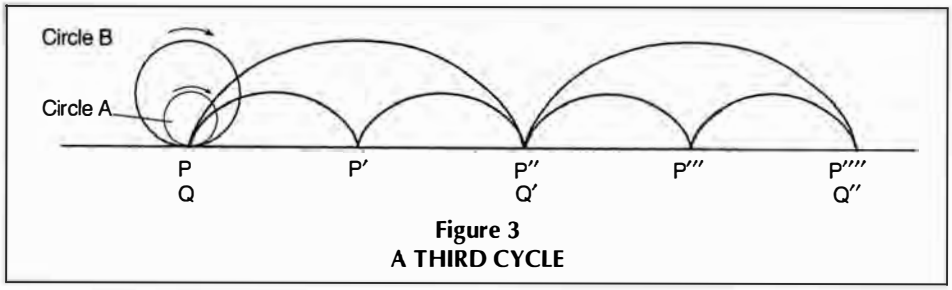


Figure 3
A THIRD CYCLE

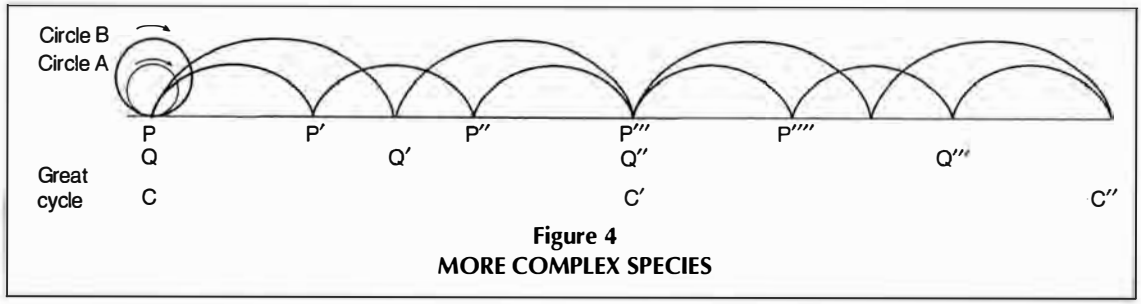


Figure 4
MORE COMPLEX SPECIES

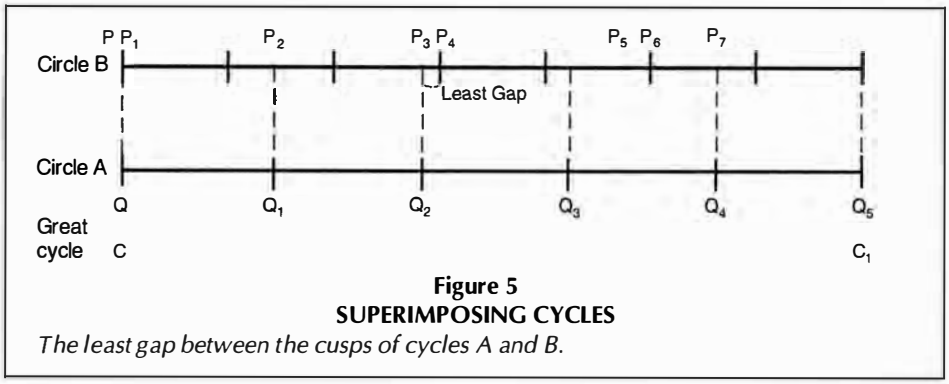


Figure 5
SUPERIMPOSING CYCLES
The least gap between the cusps of cycles A and B.

cycles *A* and *B* (as reflected in the relationship of their radii and circumferences), we can observe some significant geometrical phenomena. At this point, it is obligatory for readers to explore this domain themselves, by doing the indicated sorts of experiments, before reading further.

Consider the case, where we start the circles rolling at a common point, and with *P* and *Q* touching the line at that beginning point. In other words, $P = Q$. If the radii of *A* and *B* are *exactly equal,* then obviously $P' = Q'$, $P'' = Q''$ and so on. If, on the other hand, the radius (or circumference) of *A* is shorter than that of *B,* then a variety of outcomes is possible.

For example, the end of *A*'s first cycle (*P*′) might fall exactly in the middle of *B*'s cycle, in which case *A*'s second cycle will end exactly at the same point as *B*'s first cycle ($P'' = Q'$). The same phenomenon would then repeat itself in subsequent cycles (Figure 3).

More generally, we could have a situation, where one cycle of *B* is equivalent in length to three, four, or any other whole number of cycles of *A*. It is common to refer to this case by saying, that *A* divides *B* evenly, or that *B* is an integral multiple of *A*.

The next, more complex species of phenomena, is exemplified by the case, where the endpoint of 3 cycles of *A* coincides with the endpoint of 2 cycles of *B*. Note, that in this case *Q*′ (the endpoint of *B*'s first cycle) falls exactly between the endpoint of *A*'s first cycle (*P*′) and the end of *A*'s second cycle (*P*′), while $P''' = Q''$ (Figure 4).

The defining characteristic of this type of behavior is, that after starting together, *A* and *B* seem to diverge for a while, but eventually come back together at some later time. Insofar as the lengths of *A* and *B* remain invariant, that same process of divergence and coming-together of the two processes must necessarily repeat itself at regular intervals. (Indeed, from the standpoint of the cycles *A* and *B,* the process unfolding from any *given* point of common coincidence, taken as a new starting-point, must be congruent to that ensuing from any *other* point of coincidence.) Aha! Have we not just witnessed the emergence of a third, great cycle, *C,* subsuming both *A* and *B?*

The length of this third cycle, would be the interval from the original, common starting-point of *A* and *B,* to the *first* point afterwards, at which *A* and *B* come together again (that is, where the rotating points *P* and *Q* touch the line simultaneously at the same point). This event intrinsically involves two coefficients (or, in a sense, "coordinates"), namely, the number of cycles completed by *A* and *B,* respectively, between any two successive events of coincidence.

Seen from the standpoint of mere scalar length per se, the relationship of the great cycle *C* to *A* and *B* would seem to be, that *A* and *B* both divide *C* evenly; or, in other words, *C* is a multiple of both *A* and *B*. More precisely, we have specified that *C* be the *least common multiple* of both *A* and *B*. In our present example, *C* would be equivalent (in length) to 3 times *A,* as well as to 2 times *B*.

Those skilled in geometry will be able to construct any number of hypothetical cases of this type. The simplest method, from the standpoint of construction, is to work *backwards* from a fixed line segment representing *C,* to generate *A* and *B* by dividing that segment in various ways into congruent intervals.

For example: Construct a line segment representing *C,* and divide that line segment into 5 equal parts, each of which represents the length of a cycle *A*. Then, take a congruent copy of *C,* and divide it (by the methods of Euclidean geometry, for example) into 7 equal parts, each of which represents the length of *B*. Next, superimpose the two constructions, and

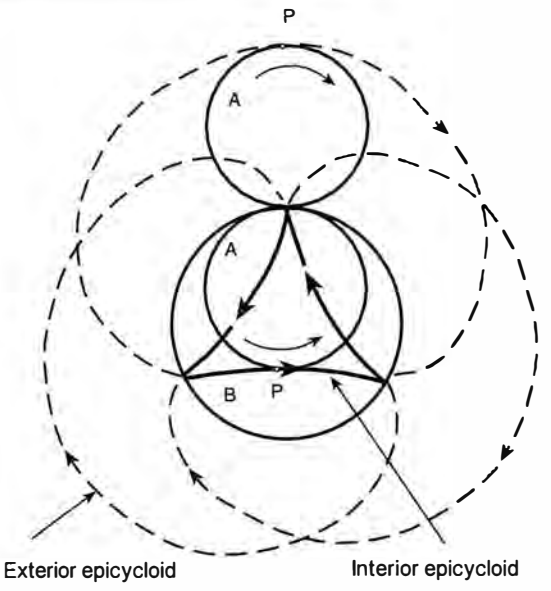


Figure 6
EPICYCLOID GEOMETRY
Circle A can be rolled along the inside or outside of B. The position of the cusp is the same in both cases. Here, the radius of A is two-thirds that of B.

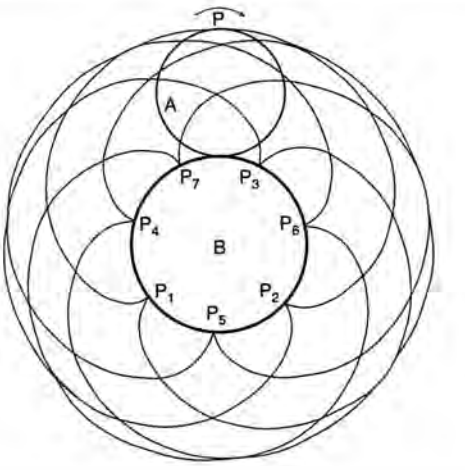


Figure 7
THE GREAT CYCLE
Circle A must roll around the outside of Circle B 5 times before a cusp falls exactly on the epicycloid's point of departure. Circle A makes 7 rotations, and in the process, produces 7 cusps, which divide the circumference of B into 7 equal arcs. Their length, 1/7 B = 1/5 A, corresponds to the common divisor of the circumferences of A and B.

observe how the set of division-points corresponding to cycles of *A,* falls between various division-points of *B* (Figure 5). Try other combinations, such as dividing *C* by 15 and 12, or by 15 and 13, for example.

Carrying out these exploratory constructions with sufficient precision, we are struck with an anomaly: the near misses or "least gaps" between cycles of *A* and *B*.

In the case of division by 7 and 5, for example, observe that before coming together *exactly* after 7 cycles of *A* and 5 cycles of *B,* the two processes have a near miss at the point where *B* has completed two cycles and *A* is just about to complete its third cycle. In terms of scalar length, three times *A* is only very slightly larger than two times *B*. For different pairs of cycles *A* and *B,* dividing the same common cycle *C,* we find that the position and gap size of the near misses can vary greatly. For example, in the case of division by 15 and 12, the least gap occurs near the beginning of the process, between the moment of completion of *A*'s first cycle and that of *B*'s first cycle. But for division by 15 and 13, the least gap occurs near the middle, between the end of *B*'s 6th cycle and *A*'s 7th cycle.

Resist the temptation to apply algebra to these intrinsically geometrical phenomena. Don't fall into the trap of collapsing geometry into arithmetic. Although we can use algebra and arithmetic to calculate the division-points and the lengths of the gaps generated by the division-points, there is no algebraic formula which can *predict* the location of the least gap! We have not yet arrived at an adequate representation of the great cycle *C* and its relationships to *A* and *B*.

Geometry Bounded by Physics

Take a new look at the circles *A* and *B,* rolling down the line. In our chosen representation, the rate of forward motion of the circles is the same, and they make a common point of contact with the line at each moment. But what is the relationship of rotation between *A* and *B?* Would it not be essentially equivalent, to conceive of *A* as rolling on the inner circumference of *B,* at the same time *B* is rolling on the line?

It suddenly dawns upon us, that the geometrical events occurring between *A* and *B* in the course of any great cycle *C* (including the phenomenon of near misses), are governed by the indicated, *epicycloid* relationship of *A* and *B* alone!

Accordingly, leave the base-line aside for the moment; instead, generate an epicycloid curve by rolling the smaller circle *A* on the inside of the larger circle *B,* the curve being traced by the motion of the point *P* on *A*. Observe, that an equivalent array of cusps is generated, in a somewhat more convenient way, if we roll *A* on the *outside* of *B* instead of on the inside (Figure 6). Experimenting with our first example of a great cycle, observe that the epicycloidal curve in this case wraps around *B* twice, before closing back on itself (dotted path of point *P* in Figure 6), while *A* completes 3 complete rotations. Also observe, that the points where *P* touches the circumference of *B*—that is, the 3 cusps of the epicycloid—divide *B*'s circumference into 3 equal arcs. Observe, finally, that the points of contact of *A,* while it is rolling, between the locations of the cusp-points of the epicycloid, include not only *P,* but also the opposite point to *P* on *A*'s circumference. In fact, each of the 3 equal arcs on *B*'s circumference correspond, by rolling, to one-half of *A*'s circumference.

Aha! That arc-length (that is, one-third of *B,* equivalent to one-half of *A*) constitutes a *common divisor* of *A* and *B*. Comparing the epicycloidal process of rolling

A against *B,* with the earlier process of *A* and *B* rolling on a common straight line, what is the relationship between the *common divisor,* just identified, and the *least gap* generated by the two cycles?

To investigate this further, carry out the same experiment with the pair of circles *A* and *B,* obtained by dividing a given cycle-length *C* by 7 and 5, respectively. Rolling *A* on the outside of *B,* we find that the epicycloid must go around *B* 5 times, before it closes on itself (Figure 7). That corresponds to the great cycle *C.* (See Figure 5.) In the course of that process of encircling *B* 5 times, the rolling circle *A* will complete exactly 7 rotations, generating 7 cusps in the process; these 7 cusps divide the circumference of *B* into 7 equal arcs, each of which is equivalent to one-fifth of the circumference of *A*. Those equivalent arcs all represent a *common divisor* of *A* and *B*.

Accordingly, construct a smaller circle *D,* whose radius is one-fifth that of *A* (or, equivalently, one-seventh that of *B*). In the course of a great cycle *C, D* makes 35 rotations. One cycle of *A* is equivalent in length to 5 cycles of *D,* and one cycle of *B* is equivalent in length to 7 cycles of *D*.

Compare this with the least gap constructed in Figure 5. Evidently, the least gap generated by *A* and *B,* is equivalent to the *common divisor* of *A* and *B,* generated by the epicycloidal construction described above. Those skillful in mathematical matters will easily convince themselves, that if *C* corresponds to the *least common multiple* of *A* and *B* in terms of length, then *D* corresponds to their *greatest common divisor*.

Evidently, *C* and *D* constitute a "maximum" and "minimum" relative to the cycles *A* and *B—C* containing both and *D* being contained in both. Out of this investigation, we learn, that *if* A and *B* have a common great cycle, then they also have a common divisor; or in other words, they are *commensurable*. Also evidently, the converse is true: if *A* and *B* have a common divisor *D,* then we can easily construct a great cycle subsuming *A* and *B*. In fact, if *A* corresponds to *N* times *D,* and *B* corresponds to *M* times *B,* then *A* and *B* will fit exactly into a great cycle of length *NM*. (The length of the minimum great cycle is defined by the least common multiple of *N* and *M,* which is often smaller than the product *NM;* for example, if $N = 6$ and $M = 4$, the least common multiple is 12, not 24.)

Return now to our original query about the possibility of uniting a "Many" of different astronomical cycles into a "One." The result of our investigation up to now is, that there will always exist a great cycle subsuming integral multiples of cycles *A* and *B* into a single whole, as long as *A* and *B* are commensurable—that is, as long as there exists some sufficiently small common unit of measurement, which fits a whole number of times into *A* and a whole number of times into *B*. Does such a unit always exist?

Remember the discovery of the Pythagoreans, of the *incommensurability of the side and diagonal of a square.* A pair of hypothetical astronomical cycles *A* and *B,* whose lengths (or radii) are proportional to the side and diagonal of a square, respectively, could never be subsumed exactly into a common great cycle, no matter how long! If we start *A* and *B* at a common point, they will *never* come together exactly again, although they will generate near misses of arbitrarily small (but non-zero) size!

This situation presents us with a new set of paradoxes: First, although *A* and *B* have no simple common great cycle, the relationship of diagonal to side of a rectangle is nevertheless a very precise, *lawful relationship.* This suggests, that the difficulty of combining *A* and *B* into a single whole does not lie in the nature of *A* and *B* per se, but in the conceptual limitations we have imposed upon ourselves, by demanding that the relationships of astronomical cycles be representable in terms of a calendar based on whole numbers and fixed arithmetic calculations.

Second, what is the new physical principle, which reflects itself in the existence (at least theoretically) of linearly incommensurable cycles? In fact, the work of Johannes Kepler completely redefined both of these questions, by overturning the assumption of simple circular motion, and introducing the entirely new domain of elliptical functions. The bounding of elementary arithmetic by *geometry,* and the bounding of geometry (including so-called hypergeometries) by *physics,* is one of the secrets guarding the gates to what Carl Gauss called "higher arithmetic."

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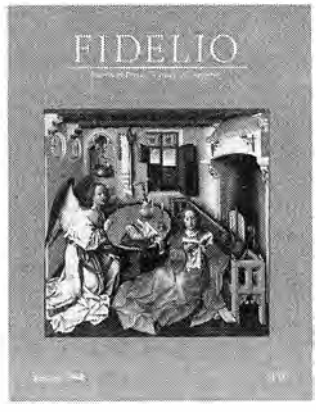

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Undermining the Foundations Of Relativity

by Rémi Saumont

L'anisotropie de l'espace
(The Anisotropy of Space)
Maurice Allais
Paris: Editions Clement Juglar, 1997
750 pp. 280 francs

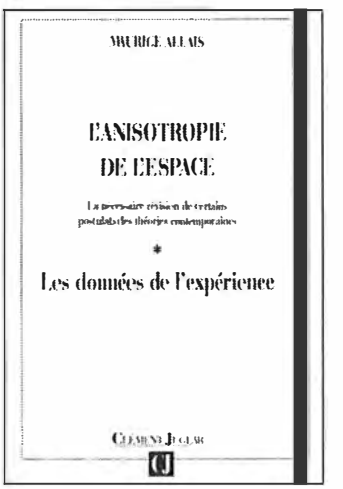
This is an important volume of more than 750 pages, which Maurice Allais has just published, in French, through Editions Clement Juglar (1997). In fact, it is the first volume of an iconoclastic work of physics reporting on experimental researches which, according to the author, will succeed in undermining the foundations of the theory of relativity.

Beginning in 1953, Maurice Allais carried out a long series of experiments studying the influence of the Earth's motion on terrestrial phenomena, experiments along the lines of the famous Michelson-Morley experiments.

One of the most original characteristics of this work, is that it is the work of an economist—and not just any economist: Maurice Allais was awarded the Nobel Prize for economic science in 1988. As a matter of fact, Allais's orientation towards economics was primarily the result of necessity—World War II—for he tells us, in the opening pages of his book, that he had originally wanted to devote himself entirely to physics. He estimates that, since 1950, he has spent at least a quarter of his time in theoretical and experimental researches in this field.

From the book's opening lines, Allais hoists his colors, asserting:

"This work will limit itself to the analysis of experimental data, the only real source of our knowledge, and, in particular, to the analysis of the new experimental data which open up new perspectives in four related domains of research: on the behavior of the pendulum, on the optical deviations of sighting



instruments and collimators, on the [hitherto] unremarked regularities in the experiments of Esclangon, and on like things in D.C. Miller's interferometric observations."

Allais insists, with equal emphasis, on the fact that, as opposed to other researches of this type, his are based on very numerous, continuous observations, day and night, carried out over long periods of time:

"The new data deduced from [these] experiments . . . appear equally incompatible with the theories of the pre-Relativistic period, and with the Special or General Theory of Relativity."

This is thus a work resolutely "out of the ordinary," which is presented to us as such, graced with a great number of citations denoting a profound knowledge of the history of science.

Allais tells us that, early on, he became convinced that gravitational and magnetic actions take place gradually, implying the existence of an intermediate medium: the ether. However, contrary to the notion which pre-relativistic physicists had of the ether, to Allais it seemed necessary to admit that this medium cannot be considered as a system of absolute reference, but that it is subject to motion with reference to the so-called fixed stars.

But it is only very succinctly, that he indicates to us how he was brought to making observations of the motion of the "paraconical" pendulum.

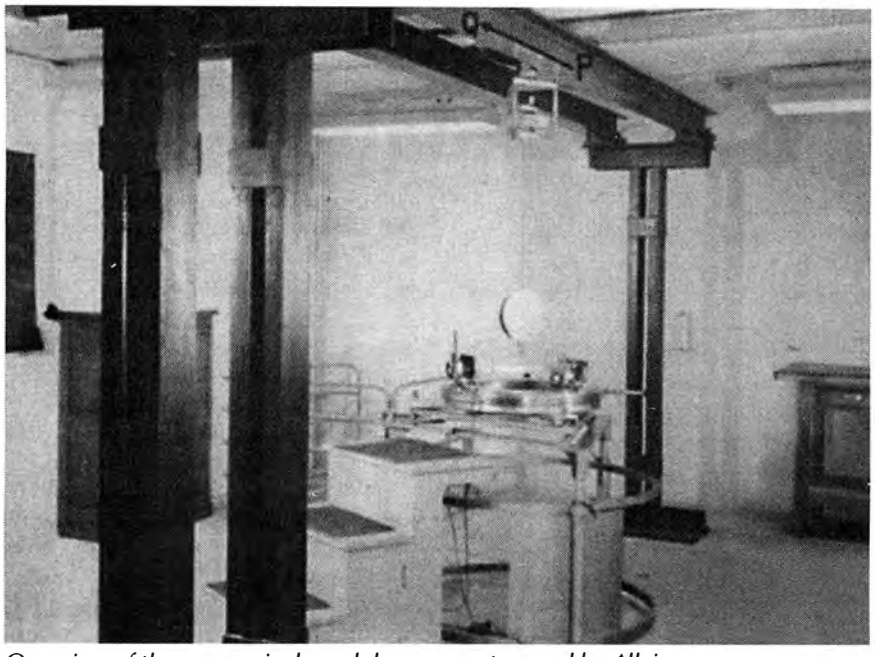
In his first researches, starting in 1950, his intention was to establish, experimentally, a relation between magnetism and gravitation, by observing the effect of a magnetic field on the movement of a pendulum made of a glass ball. These experiments did not give him significant results. On the other hand—as happens so often—the most interesting thing came in as something subsidiary, merely noticed, whose existence had not been foreseen, and, consequently, was not further researched: Namely, that the movements of the pendulum he first studied, in order to compare its motion to another one, in the absence of a magnetic field, "could not be reduced to the Foucault effect, but presented very important anomalies, which varied over time."

Thus it was this unexpected observation, that led to the researches which constitute the subject of this book.

Allais's Experiments

The pendulum used was characterized by the author as "paraconical" because its suspension consists of a ball-bearing, 6.5 mm in diameter (the amplitude of release was 0.11 radians, to prevent the ball-bearing from sliding). The envelope of the various extreme positions of this pendulum had the approximate form of a conic surface.

Unlike the Foucault pendulum, installed under the cupola in the Parisian Pantheon, and because of the particular suspension of Allais's pendulum, its motion (especially that motion he calls isotropic) with respect to the Earth, is not subjected to significant forces tending to



Overview of the paraconical pendulum apparatus used by Allais.

restore equilibrium. In fact, in the contrary case of the Foucault pendulum, where the plane of oscillation turns relative to the Earth (theoretically, remaining unchanged with respect to the fixed stars), a torsional force develops in the suspension wire that causes perturbations in the experiment.

Nothing of the sort is produced in the case of Allais's pendulum. There, the orientation of the plane of oscillation depends, in principle, in the case of the "isotropic" pendulum only upon the structure of the inertial-gravitational field—Coriolis effects having been taken into account.

Allais's experiments were conducted from 1953 to 1960, in a laboratory in the basement of the Iron and Steel Research Institute (IRSID) at Saint-Germain, and, starting in 1958, in a subterranean quarry (under 57 meters of rock) in Bougival.

The photographs of the experimental apparatus are not very clear, and a good series of drawings would have been much better. Nonetheless, its description is sufficiently detailed.

In order to minimize the causes of error which might have come from the irregular wear on the ball-bearing, it was changed regularly. The same is true for the platform on which it rests.

The pendulum was released every 20 minutes from a position of rest by burning a string. Its movement was observed for 14 minutes, through a sight calibrated to the azimuth of the plane of oscillation, with a precision on the order of a tenth of a degree. The pendulum was then stopped and released again after 6 minutes, in the plane of the last observed azimuth—and this was done night and day, during observation sessions during one month.

Actually, all of the experiments of the first series (during a four-year period), were done with a so-called *anisotropic* pendulum. This is similar to the one described above, except that in the anisotropic (unlike the case of the isotropic), the rotation of the plane of oscillation was not totally free, but was limited to 210 grades [400 grades equal 360 degrees.] Moreover, the support for the system was made in such a way that a slight difference in its elasticity occurred in two perpendicular planes. Thus, a slight force tending to restore equilibrium did exist, and this tended to turn the plane of oscillation to an azimuth of 171 grades, counting clockwise from due north.

As a result, whenever the pendulum was released in a plane along an azimuth other than 171 grades, the pendulum's motion would have a slight tendency to describe a very flattened ellipse. Thus, it was the major axis of this ellipse which became the basis for measurement.

It was the variation of the azimuth, as a function of the time, and the orientation of the response to the equilibrium-tending force, which was studied first. Allais tells us:

"During the course of an uninterrupted series of observations, the tendency of the plane of oscillation was not to fix itself in the neighborhood of the direction of anisotropy of the support, for example, but the variation of its azimuth as a function of time, presented itself as an oscillation that appeared to be very regular, at least at first sight."

In certain cases, the shift of the azimuth appeared to be considerable, and might have reached 100 grades.

Thus, the choice of experimental criteria that Allais kept for this series of experiments, appears to be somewhat unusual and difficult to discuss, because the reasons for such a choice are not given in detail, except in a short subchapter that comes later in the book—pp. 171-182.

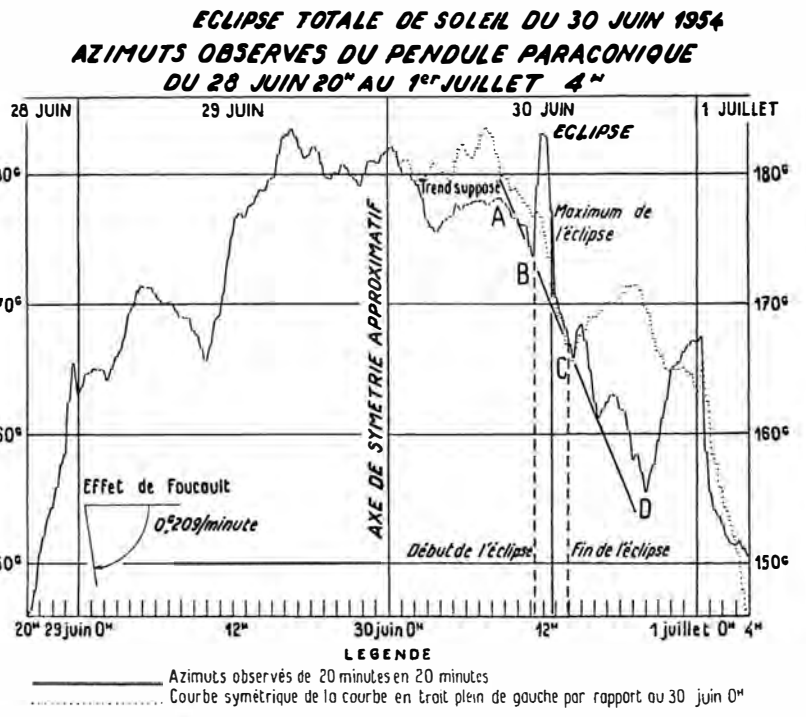
Fortunately, a second volume has been announced, which will be perhaps more explicit. A summary of this book is provided us in the second part of the table of contents of the present volume.

Several Periodicities Seen

The results of this first series of experiments show the existence of several periodicities, of which an analysis has been made by statistical methods. The principal periodicities of 24 hours, and 24 hours and 50 minutes, correspond to waves K1 and M1 in the theory of tides. These are thus classified as luni-solar by the author. What is remarkable, is their amplitude.

One knows, in effect, that the field of solar and lunar gravitation must play a role in the movement of a pendulum at the surface of the Earth, but according to Newtonian theory, later corrected and updated by relativity theory, these effects would be very slight, and not of the magnitude found by Allais. This is one of the reasons that his experiments are so interesting.

Pages 118 to 136 provide us with calculations concerning such phenomena, looked at from the standpoint of classical physics. Then comes an extremely short discussion of the possible causes of error. The only cause proposed, and then refuted, concerns the possible defects in the level of the platform on which the suspension ball-bearing rests. This is perhaps discussed a little too summarily, but it will be taken up again in the final



AZIMUTHS OF PARACONICAL PENDULUM OBSERVED DURING TOTAL ECLIPSE OF THE SUN, JUNE 30, 1954

During the 1954 total eclipse, Allais observed that the plane of oscillation of his pendulum turned sharply by 15 grades, and then returned to its previous azimuth.

chapter. However, the similitude of the results obtained at Saint-Germain, and at Bougival in the "Blanc Mineral" quarry, 60 meters underground, shows that we must exclude a host of other potential culprits.

In this regard, and to broaden the discussion, I would pose the following question: How is it possible, that the gyroscopic compass, in such widespread use today, seems not to have shown anything to date, that is at all similar to Allais's findings? Is it then that the lunisolar effect on the pendulum, found by Allais, does not perturb the gyroscope, even though the two instruments are supposed to have in common, the capability of serving as an angular inertial reference plane? What must one conclude from that?

If there was still some doubt about the reality of the effects observed by Allais, the remarkable facts that occurred during two eclipses of the Sun, even though the author appears to minimize their importance, bring out an element worth noting to the results of his research taken as a whole. During the course of the first eclipse in question (the total eclipse of June 30, 1954), for example, the plane of oscillation of his pendulum turned brusquely by 15 grades, only then to return to its previous azimuth. An analogous effect was noted during the eclipse of Oct. 2, 1959.

Inertial-Gravitational Equivalence

In the conclusion to his chapter on the anisotropic suspension pendulum, Allais analyses the arguments posed against him. He then draws from the results obtained, the conclusion that inertial space is anisotropic.

Here lies, its seems to me, a problem of interpretation. Is it a question of inertial anisotropy, or of gravitational anisotropy? According to general relativity, one is forced to think of inertia and gravitation in the same breath—that is the famous principle called equivalence, between gravitation and inertia. We forget that, even from the point of view of relativity, the equivalence is strictly local.[1] On an astronomical scale, the mechanisms which correspond to these two phenomena must be differentiated, because they do not have the same dimensional representation, intrinsically speaking.[2] The reported anisotropy, therefore, would seem to be gravitational, rather than inertial, because it seems that the gyroscope is not affected.

In the second phase of his experimentation, Allais wants to determine in a rigorous manner, the direction of spatial anisotropy manifested, without having to worry about the anisotropy of his pendulum, whence he turned this pendulum into one that was completely isotropic; that is, without any equilibrium-tending effect in any chosen plane of oscillation. This required installing some equipment, quite large and heavy, that was tested immediately in a series of correlating experiments. The results he obtained, corroborated the earlier ones.

The measurements carried out during the eclipse of 1959, for example, made it possible to confirm that one effect of eclipses, is to rotate the plane of oscillation of the pendulum towards the Moon and the Sun (p. 316).

In general, there would exist at any moment, a preferred direction towards which the plane of oscillation of the pendulum would tend to displace itself, and this direction would vary with the course of time, as a function of the astronomical conditions of the moment.

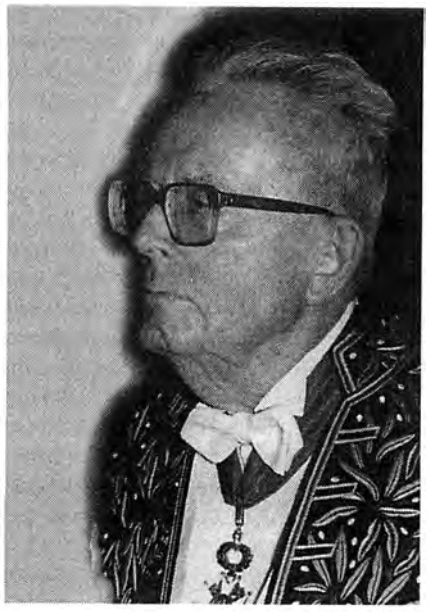
The Consequences of His Work

Thus, these results taken together would indicate the existence of an anisotropy of physical space, where the direction is variable over time, but whose mean direction would be oriented East to West.

Allais has provided us with a detailed description of these different observations and calculations, a description which takes the form of laboratory reports, the study of which, one must say, is quite arduous and detailed, because it requires specialist technical knowledge beyond that of the average reader, or even a scientist.

As for these minutiae in the exposition of each element of the results, we must perhaps attribute them to a desire for rigor, perhaps somewhat exacerbated by the opposition that he found within the scientific community. In this regard, Allais tells us an anecdote, not lacking in flavor. He cites the following passage from a rejection letter sent him by Jean Leray:

"The publication of your notes, wherever that might take place, will cast



"The new data deduced from [these] experiments . . . appear equally incompatible with the theories of the pre-Relativistic period, and with the Special or General Theory of Relativity."
—Maurice Allais

doubt onto the methods which you employ, not only in the physical, but also in the economic sciences; in this sense, their publication might be useful."

Allais adds acerbically: "I wonder what his reaction was when I was awarded the Nobel Prize in economics."

We must admit that the notes rejected for publication by Leray, concerned a very particular subject, whose technical approach seems to be only perfectly understood and mastered, by specialists in topographical geography, or by a few astronomers or opticians: "The deviations of optical sights and collimating lenses."

If one were to judge it by the manner in which Allais expounds his method and his results at the beginning of Chapter 3, Leray might perhaps have been somewhat right in being reticent. Indeed, Allais does not include an explanation to teach us the technique that he utilized, or the reasons behind it; but, above all, neither does he give us anything that might justify the manner in which he was able to interpret the results obtained. Hence, these results and their final interpretations are delivered to us in crude form, without its being made easy for us to appreciate, critically, their validity. It is clear that Allais wants to be believed on his word. You have to keep reading his book, and then further on, when he is talking about the experiments of Esclangon and Miller, you discover some developments whose particulars, had they figured at the head of the chapter in question, would have made it much more comprehensible.

That is the major defect of the book, otherwise very original and interesting: The cart is often put before the horse, and in order to read the book more easily, and with pleasure, you have to go hunting in later chapters, for what should have been laid out in the first, as a preliminary.

Allais tells us that it was the experimental work of Esclangon, as much as that of Miller, which led him to the conclusion of a dissymmetry of optical space.

The first, published in 1928, concerns 40,000 measurements made in the course of a series of 150 observations, made by day and by night. The experiment involved alignment of a horizontal wire and its mirror image, sighted through the telescope at the Strasbourg observatory. This series of observations was carried out first in the direction northeast, and then northwest. A systematic difference was found in the readings in the two directions, a difference which depended upon the mean sidereal time of the period of observation, and which corresponded to a sinusoidal fluctuation with a period of 24 sidereal hours. The conclusion to be drawn from these observations, thus, would be that space is optically anisotropic.

Dayton Miller's Experiments

The interferometric observations of Miller proceed from the same philosophy. They were carried out between 1925 and 1926 at the Mount Wilson Observatory in California. They were all in the tradition of the celebrated experiments of Michelson and Morley. Hence, their aim was to determine if it were possible to experimentally discern a translation of the Earth with respect to the ether, by using interferometry to measure its velocity. Allais does tell us, this time very explicitly, the methodology and results of these researches, demonstrating that there again, the experiment came down to measuring the velocity of light, in two perpendicular directions. However, unlike the preceding experiments carried out at Mount Wilson—and he insists on this point—here the observations were carried out, in a completely continuous manner, to all azimuths, and at every moment of day and night, over long periods of time. Thus, he considers these experiments more decisive, than those of brief duration, which were used for the confirmation of the isotropic propagation of light.

Allais then applies himself to a scrupulous study of the results, the which permit him to isolate the periodicities not perceived by the authors of the observations, in particular, a semi-annual and annual periodicity in sidereal time, not noticed by Miller.

Beginning with these analyses, Allais notes the great coherence that exists between the observations of his pendulums, the optical observations with telescope sights, the observations of Esclangon, and the interferometric observations of Miller—a coherence whose principal characteristic is that there exists a very strong correlation with the position of the Earth in its orbit.

Allais concludes from this, that any theory that rests on foundations which are incompatible with the temporal periodicities and patterns that he established (Relativity Theory, for example), must be rejected, and that the possibility of determining the position of the Earth in its orbit, by purely terrestrial experiments, would follow from what has already been demonstrated experimentally.

Conclusion

Space must thus be considered as endowed with an anisotropy caused by the stars and the solar system, with the result that, contrary to what is now believed, the velocity of light would not be the same in all directions. The differences noted would be as much as on the order of 10^{-5}, that is, about 3 km/sec. (It should be mentioned, that that velocity, is within the range of error in measuring the speed of light, foreseen by A. Kastler, for example.)

So, if we agree with the author, these conclusions would impose a return to the conception of an intermediary milieu, that is to say the ether of Fresnel, of Faraday or Maxwell—but with this dif-

ference: that one should consider the medium as itself being able to be the locus of relative motion.

This is clearly an affirmation which goes wholly against the reigning concepts of current physics. At this time, in fact, the ostracism of the anti-relativists has no parallel, except for the ostracism that formerly was applied against the original proponents of relativity.

Nevertheless, even if Maurice Allais were wrong—which merits discussion, because it involves experimental facts—Allais's book is of great interest, if only because of the wealth of the author's erudition. One must hope that this great work will have a distribution commensurate with the importance of the problems that it raises, and that the deadweight of "scientific correctness" will not, in this case, become a hermetically sealed cover for the book. If Maurice Allais turns out to be right, his work would lead to a major scientific revolution.

We await with impatience the appearance of the second volume of this work.

Rémi Saumont is a research director emeritus at INSERM, France's main medical research institute, in Paris. The former leader of its biophysics laboratory, he is now working on physical and mathematical questions. One of his main research interests is dimensional analysis and the theory of measurement. His review first appeared in the French-language Fusion *magazine, Jan.-Feb. 1998, p. 47. It was translated into English by Marielle Hammett Kronberg and Rick Sanders.*

Notes

1. See M. A. Tonnelat, *Les principes de la théorie electromagnetique et de la relativité*, Paris: Masson.
2. Rémi Saumont, "The Generalization of the Laws of Physics," ("La généralisation des lois de la physique") *Fusion*, No. 49, Jan.-Feb., 1996.

Did You Miss?

Maurice Allais on
"The Experiments of Dayton C. Miller (1925-1926) and the Theory of Relativity" and
"On My Experiments in Physics, 1952-1960"
in

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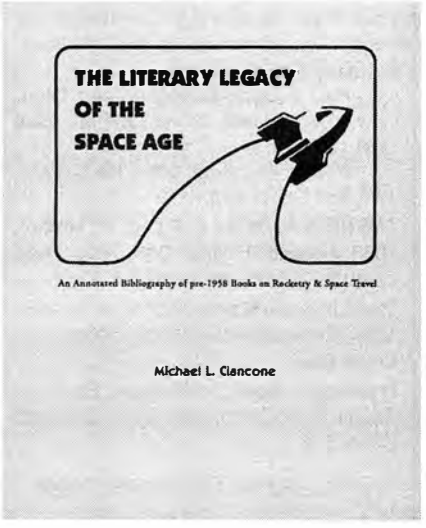
Michael L. Ciancone
Houston: Amorea Press, 1998
Softcover, 70 pages, $20



With the launch of Sputnik in October 1957, the space age began. But for decades before 1957, men of vision and imagination had visualized what this new field of activity would require, and what it might mean for mankind.

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—Marsha Freeman

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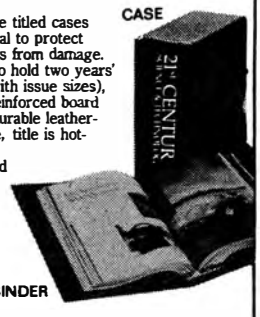

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BOOKS RECEIVED

Creative Evolution, by Henri Bergson. Mineola, N.Y.: Dover Publications, 1998. Reprint of 1911 edition. Paperback, 407 pages, $12.95.

Evolutionary Ecology Across Three Trophic Levels—Goldenrods, Gallmakers, and Natural Enemies, by Warren G. Abrahamson and Arthur E. Weis. Princeton: Princeton University Press, 1997. Paperback, 456 pages, $29.95.

Naked to the Bone—Medical Imaging in the Twentieth Century, by Bettyann Holtzmann Kevles. Reading, Mass.: Addison-Wesley, 1998. Paperback, 378 pages, $18.00.

Three-Dimensional Geometry and Topology, Vol. 1, by William P. Thurston. Princeton: Princeton University Press, 1997. Hardcover, 311 pages, $39.50.

Trigonometric Delights, by Eli Maor. Princeton, N.J.: Princeton University Press, 1998. Cloth, 236 pages, $24.95.

Five Golden Rules: Great Theories of 20th-Century Mathematics—And Why They Matter, by John L. Casti. New York: John Wiley & Sons, 1997. Paperback, 235 pages, $16.95.

Interpreting the Quantum World, by Jeffrey Bub. New York: Cambridge University Press, 1997. Hardcover, 298 pages.

Physical Chemistry—A Molecular Approach, by Donald A. McQuarrie and John D. Simon. Sausalito, Calif.: University Science Books, 1997. Cloth, 1270 pages, $76.00.

AURA and its U.S. National Observatories, by Frank K. Edmondson. New York: Cambridge University Press, 1997. Hardcover, 367 pages.

History of the International Atomic Energy Agency: The First Forty Years, by David Fischer. Vienna: IAEA, 1997. Hardcover, 550 pages.

International Atomic Energy Agency: Personal Reflections. Vienna: IAEA, 1997. Hardcover, 331 pages.

The Code of Kings—The Language of Seven Sacred Maya Temples and Tombs, by Linda Schele and Peter Mathews. New York: Scribner, 1998. Paperback, 418 pages, $40.00.

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- Should the Laws of Gravitation Be Reconsidered? *by Maurice Allais*
- Nonlinear Structures in the Ocean *by Robert Stevenson*
- Science Is Not Statistics *by Lyndon LaRouche*
- The Manic Sun *by Nigel Calder*

AMERICAN ASTRONAUTICAL SOCIETY BOOKS ON SPACE

Prospects for Interstellar Travel, By J. H. Mauldin, 1992, 390p, Hard Cover $50.

The book reviews most of the serious published literature on interstellar travel and is a source book for professional and amateur scientists and engineers, educators and students seeking to study a problem that integrates many fields. The book also advances the literature with new ideas and findings and provides novel tools for understanding the scope of the problem. Extensive bibliography. Index.

Working in Orbit and Beyond: The Challenges for Space Medicine, Ed., D. B. Lorr, V. Garshnek, C. Cadoux, 1989, 188p, Hard Cover $22.50, Soft Cover $17.50

Topics covered are: the differences in normal physiology and adaptation to zero gravity, the special hazards of life and work in space, their countermeasures, and future challenges in space medicine.

BOOKS ON MARS

These volumes provide a blueprint for manned missions to Mars and a continued presence on the planet's surface, including what technology is required, and what kinds of precursor missions and experiments are required.

The Case for Mars III, Strategies for Exploration, Consists of two volumes. Ed., C. Stoker, 1989

Part I, General Interest and Overview, 744p, Hard Cover $37.50; Soft Cover $27.50.

Part II, Technical, 646p, Hard Cover $35; Soft Cover $25.

The Case for Mars II, Ed., C. P. McKay, 1985, Second Printing 1988, 730p, Hard Cover $30; Soft Cover $20

The Case for Mars I, Ed., P. J. Boston, 1984, Second Printing 1987, 348p, Hard Cover $45

The NASA Mars Conference, Ed. D. B. Reiber, 1988, 554p, Hard Cover $25; Soft Cover $15.

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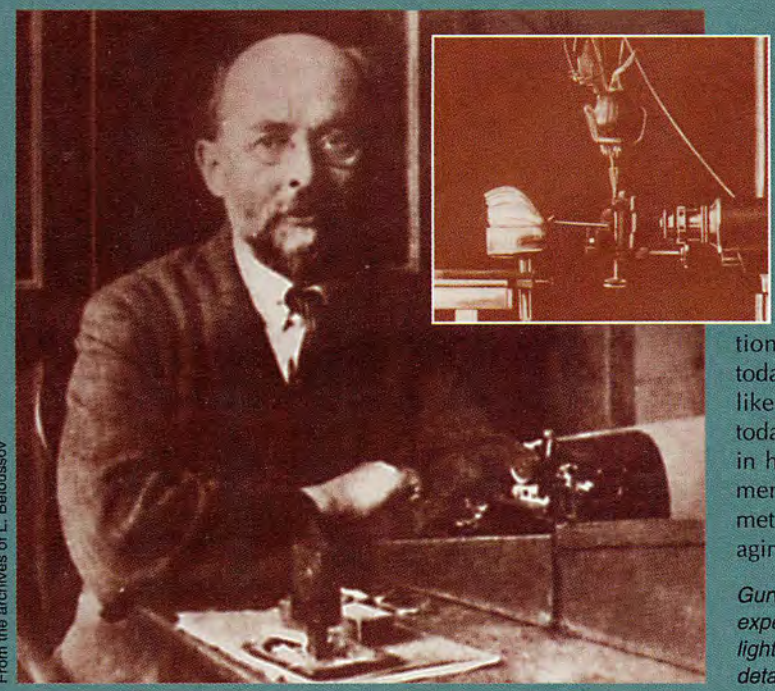


From the archives of L. Beloussov

LEARNING FROM THE FATHER OF BIOPHYSICS

Most readers, including those in the biological sciences, will not be familiar with Alexander Gurwitsch (1874-1954), the Russian biologist whose pioneering work forms the basis for optical biophysics, and for investigations into the electromagnetic organization that is specific to living systems. In an extraordinary paper, one of Gurwitsch's students, Michael Lipkind, discusses the importance of Gurwitsch's thinking and his work.

Gurwitsch's method runs contrary to the reductionist Aristotelian approaches that dominate biology today, and provides a fruitful guide for those who would like to free themselves from the Aristotelian axioms of today's science, as molecular biologist Colin Lowry notes in his introduction. Economist Lyndon LaRouche's commentary elaborates on the importance of Gurwitsch's method for studying—and conquering—the diseases of aging and others, such as AIDS.

Gurwitsch in his laboratory. Inset is Gurwitsch's famous onion experiment, where he showed that some onion tip cells emit light to regulate the division of other cells. *(See page 50 for details.)*

NASA

Islands off the coast of Jakarta, Indonesia. Inset: The atolls of the Maldive Islands in the Indian Ocean, a favorite target of the global warming propagandists, who claim that the islands will be inundated by ice melt.

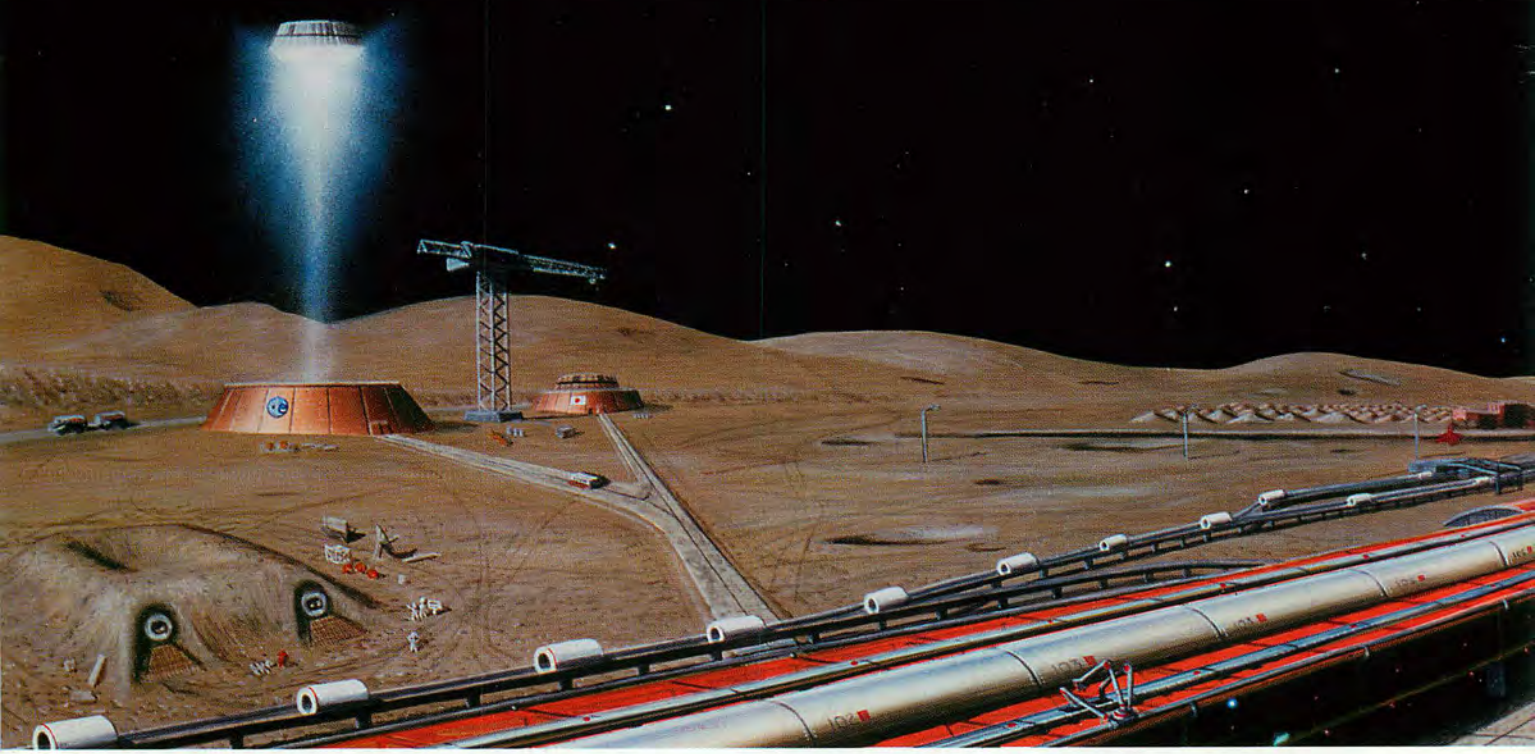
GLOBAL WARMING WILL *NOT* CAUSE FLOODING

The next time you hear people talk about global warming causing the Antarctic Ice Sheet to melt, inundating low-lying areas around the world, and causing waves to lap at the steps of the White House, ask them if they expect global temperatures to go up to 210°F. Because, as marine geologist Richard Terry explains, that's what it would take to get Antarctica's −50° temperatures up above freezing. Not only that, but the melting process would take 5,000 years. And if the global-warming hysteria persists, Terry's article has enough reality-based information to calm down any reasonable person.

In This Issue:

SELENOPOLIS YEAR 20??

If we had followed the advice of visionary space scientist Krafft Ehricke in the 1970s, this cover illustration could have been you and your child in Selenopolis today! But, it's not too late. We can still go back to the Moon to civilize it. As Marsha Freeman reports, all we need is the political will to put the necessary science and technology programs into high gear.

Colonizing the Moon is man's "extraterrestrial imperative," as Ehricke put it, and it was his life mission. Born in Berlin in 1917, by the time he was a teenager, he had started an amateur rocket society. He contributed to the development of the world's first space vehicle, the V-2, at Peenemünde, during World War II. In America, Ehricke worked in the aerospace industry for Rockwell International, and for the Convair Division of General Dynamics, where he developed the Centaur rocket.

The plans are on the drawing board, but carrying out Ehricke's vision requires a reversal of the cultural pessimism that has infected the United States in the last quarter century.